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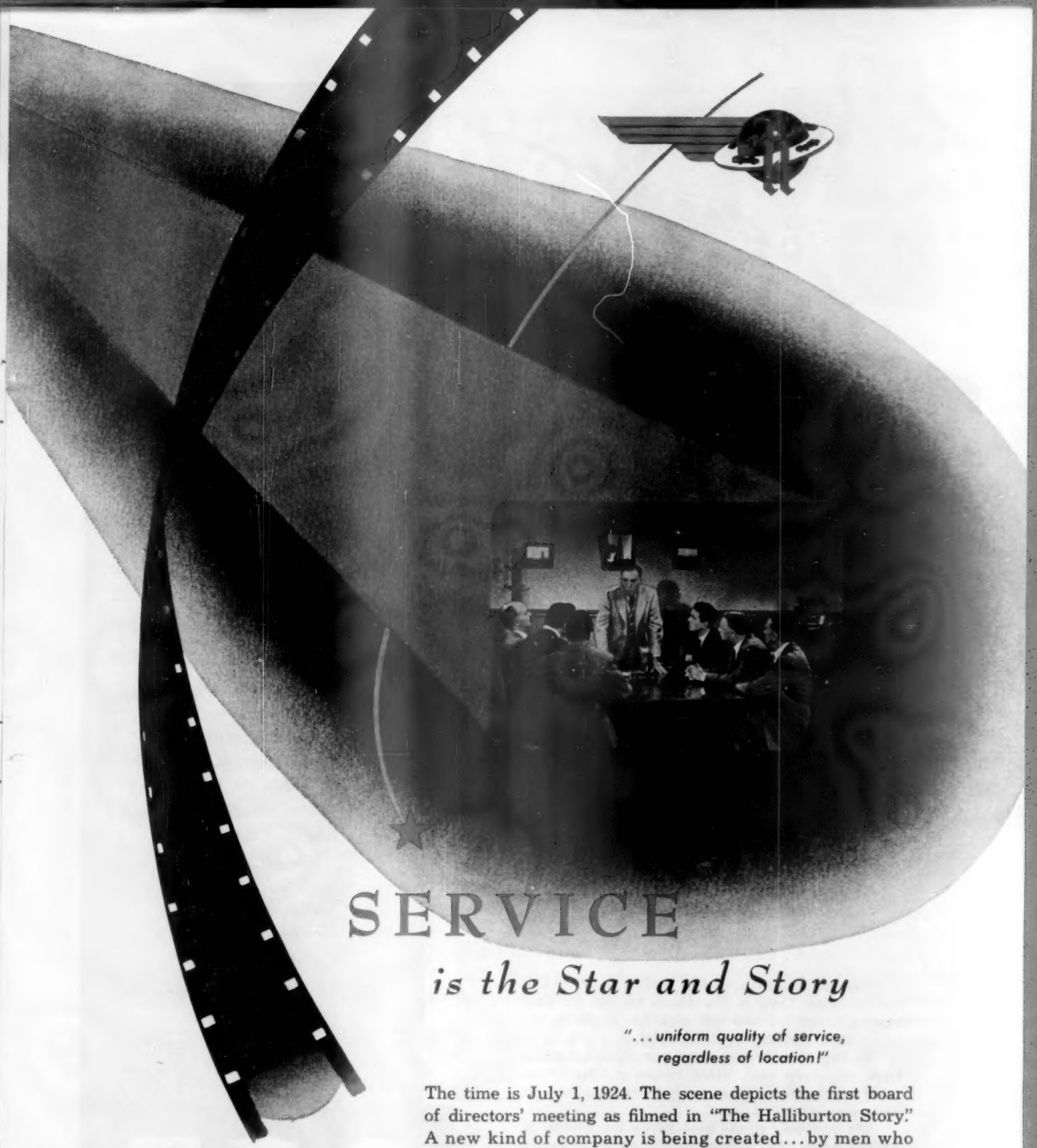

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On the Cover: We believe that Faith of the Engineer is an excellent statement of the creed which the engineer must live by in order to assume his place in society as a professional man. It is well for each engineer to take stock from time to time, comparing the principles he follows to those in this statement. A. B. Parsons, former secretary of AIME, is the author. Reproductions of this statement for framing can be obtained from the Petroleum Branch office.

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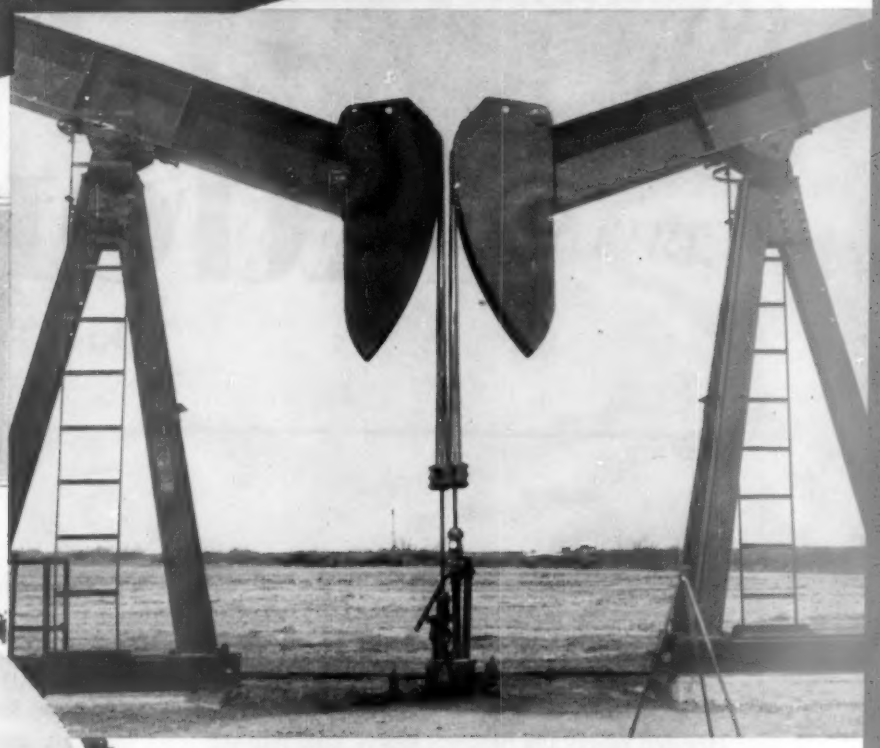

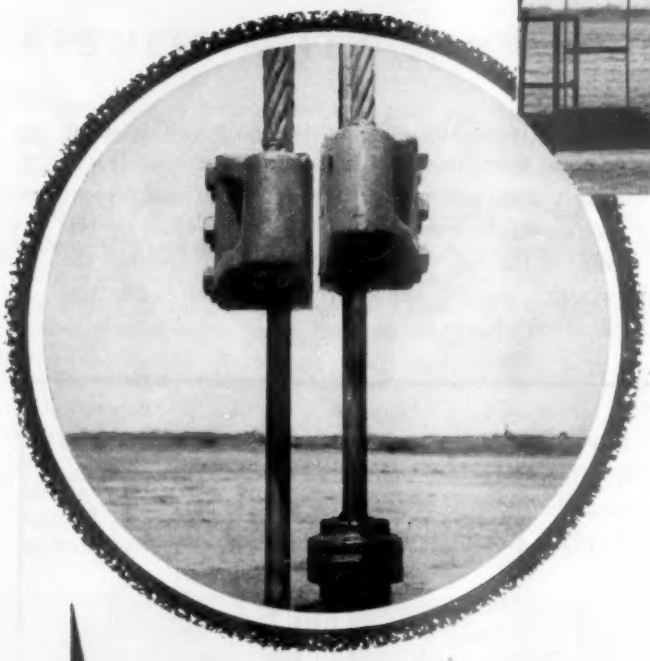

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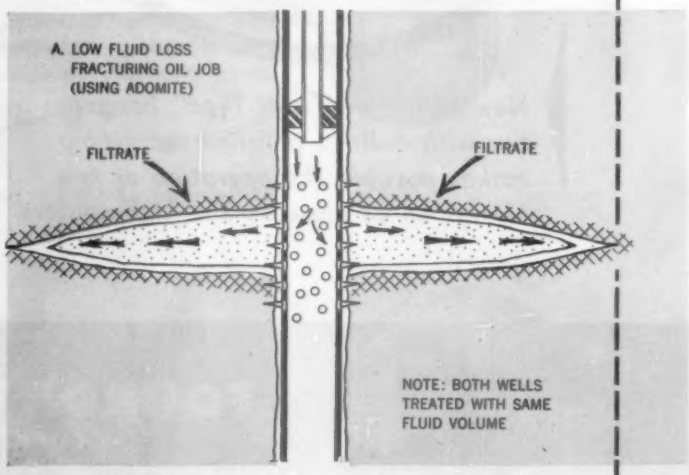

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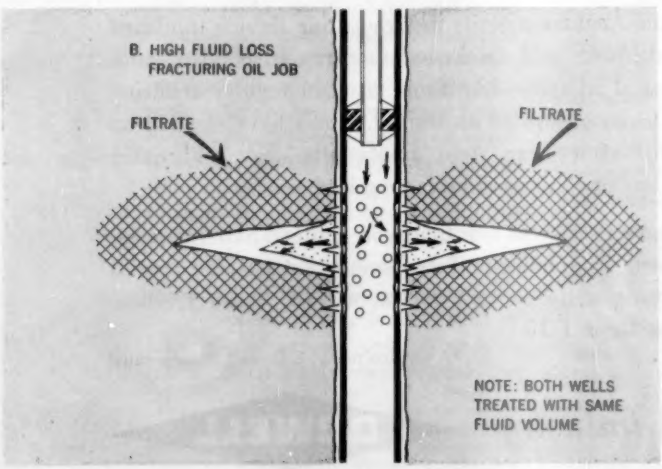

2. Increased Production—*West Texas.* Well fractured with 10,000 gallons Adomite-treated lease crude and 20,000 pounds sand. Production increased from 75 to 576 BOPD.

3. Refracturing—*Kansas.* Well fractured with 10,000 gallons Adomite-treated lease crude and 12,000 pounds sand. Flowed 216 BOPD. This was third time well had been fractured, the two previous times having been with conventional fluid. Well had been shut in before fracturing.

4. Difficult Treating Area—*South Louisiana.* Well fractured with 10,000 gallons Adomite-treated lease crude and 10,000 pounds sand. Production increased from 0 to 160 BOPD. Previous fracturing in area sanded out at less than 2,000 pounds sand with conventional fluid.

5. Reduced Treatments—*West Texas.* In a field, 10,000 gallons of Adomite-treated crude oil injected at 8 bbl./min. gave as good, or better, results than were obtained in offset wells treated with 20,000 gallons conventional type fluid, injected at 40 bbl./min.

6. High Bottom Hole Temperature—*South Texas.* Adomite-treated lease crude has been used to put away 6,000 pounds sand in a formation having a temperature of 245°F. Ordinary fluids break down at this temperature.

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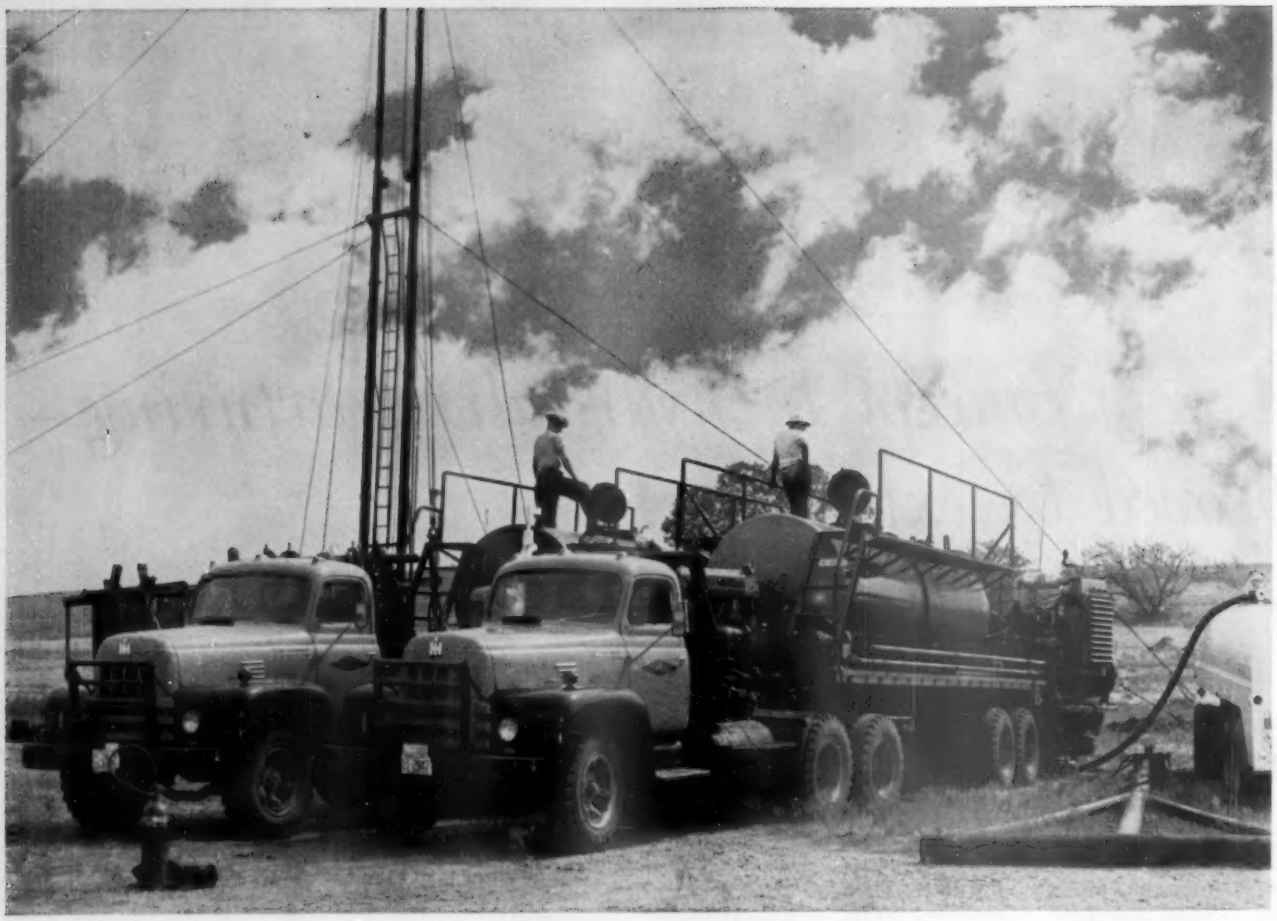

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FEATURE ARTICLE

LIGNOSULFONATE STABILIZED EMULSIONS in OIL WELL DRILLING FLUIDS

W. C. BROWNING | MARATHON CORP. ROTHSCHILD, WISC.

Abstract

Oil-in-water emulsions have become important in oil well drilling fluids. Lignosulfonates, prominent among various stabilizing agents, have been used successfully for several years in both lime-base and brine-base fluids. This paper is concerned with the surface active properties of the lignosulfonates, the characteristics of lignosulfonate stabilized emulsions, and their application to oil well drilling.

Lignosulfonates in solution may be regarded as subcolloidal, high molecular weight polyelectrolytes. They do not possess the hydrophobic-hydrophilic molecular structure or other attributes of the McBain "colloidal electrolyte." In general, lignosulfonates are not effective in lowering surface or interfacial tension of water solutions, but certain sodium lignosulfonates when used in combination with alkaline brines may lower interfacial tension.

Lignosulfonates stabilize emulsions because the lignosulfonate molecule is adsorbed at the oil-water interface, establishing a high order electrokinetic charge and also a semi-rigid film. Lignosulfonate stabilized emulsions are stable in high concentrations of inorganic electrolytes, stable to heat, freezing, and to mechanical action.

Drilling fluids with lignosulfonate stabilized emulsions may be prepared to control water loss independent of bentonite or organic colloids such as starch. Such fluids may possess low viscosity, low weight, and low water loss simultaneously. These fluids have low mud-making properties and are unaffected by the usual inorganic contaminants, yet if desired may be adjusted to raise viscosity and gel to form high weight muds.

A more complete understanding of the lignosulfonates and their potentialities may well aid in the development of drilling fluids designed to cope with certain of the many problems encountered in oil well drilling.

Manuscript received in Petroleum Branch office on Aug. 2, 1954. Paper presented at Petroleum Branch Fall Meeting in San Antonio, Oct. 17-20, 1954.

Introduction

Emulsion muds may be defined as water-base drilling fluids to which oil has been added and subsequently emulsified. These muds are relatively new to oil well drilling, the literature being rather meager until about 1949.[1,2,3,4] Field use in recent years has brought emulsion muds into prominence as important and useful drilling fluids, but full knowledge of their potentialities is yet to be realized.

It is now recognized that emulsion muds differ widely and that their properties depend upon the emulsifier used. Among the various chemicals used to condition drilling muds, the calcium lignosulfonates have achieved a position of importance, especially with lime-treated muds. The usefulness of the metal salts of lignosulfonic acid is not limited to deflocculating such lime muds—their properties as emulsifying agents are also worthy of attention.

Lignosulfonate stabilized emulsions were deliberately used in March, 1949, to control the water loss in lime-treated muds, and the usual advantages of emulsion muds were noted—i.e., reduced torque on the drill stem, increased drilling rate, increased bit life, improved borehole conditions, etc. Lignosulfonate stabilized emulsions in saturated brines were introduced in 1951 and have been found desirable as workover fluids.

Some of the salient characteristics of lignosulfonates as emulsifiers are presented in this paper.

[1]References given at end of paper.

Chemistry of the Lignosulfonates

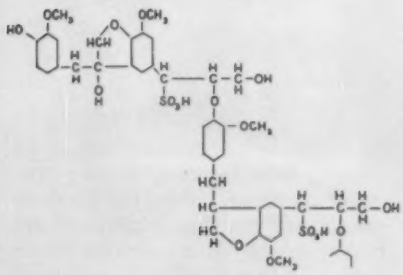
A discussion of the lignosulfonate compounds as emulsifying agents should include their chemical composition to afford comparison with the action of soap and other emulsifying agents. No attempt will be made here to go into detail concerning the organic structure of lignin and lignosulfonic acid, so ably discussed elsewhere.[5] It should be remembered, however, in any discussion of lignosulfonates the importance of wood source, the degree of purification, molecular weight fraction, and modification by oxidation, sulfonation, or desulfonation—all determine the properties of the final product. The lignosulfonates discussed in this paper were derived by the Marathon-Howard Process[6] from softwoods.

Lignosulfonates are hetero-disperse polymers whose molecular weight varies between 1,000 and 20,000. Lignosulfonates are quite soluble in water. Water solutions of 50 per cent or more by weight are readily obtained. Dilute water solutions give no Tyndall effect indicating the subcolloidal dimensions of the lignosulfonate molecule. Exami-

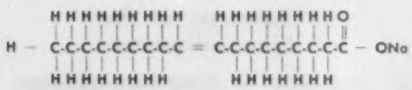
nation of lignosulfonate films from water solution at magnifications of 25,000 diameter or more by means of the electron microscope fails to reveal any identifiable structure. X-ray work has shown the lignosulfonate molecule to be completely amorphous.

The organic structure of a complete lignosulfonate compound has not been determined, but it is known that the basic lignin monomer unit is a substituted phenyl propane.

A possible section of the polymeric lignosulfonic acid could have the following structure:



It is apparent from the above structural formula that a lignosulfonate will differ considerably in properties from a compound of the sodium oleate type:



where the long hydrocarbon chain is soluble in the oil phase and has a definite hydrophile-lipophile balance number. The metal salts of lignosulfonic acid because of their complex structure have no oil soluble chains to orient them in an oil-water interface.

Our investigations have failed to reveal any evidence of micelle formation. Plots of specific conductivity against the square root of concentration yield only smooth curves, whereas typical colloidal electrolytes, such as sodium oleate, give the characteristic break at the point of critical micelle concentration. No solubilization phenomenon has been observed, again indicating that the lignosulfonates do not form micelles.

Viscometric analyses made by Rothschild of pure dilute lignosulfonate solutions have not shown any evidence of extensive molecular hydration but have revealed a pronounced and powerful electroviscous effect. The viscometric analyses indicated a shape factor of about 5 to 9 for the lignosulfonates, indicating only a minor ellipsoidality of the lignosulfonate molecules. Above 4 per cent concentration in water solution, association of the lignosulfonate molecule occurs which causes the solution viscosity to rise at an increasing rate. The effect of these association colloids on viscosity is not comparable with the typical high polymer: 30 per cent calcium lignosulfonate solution, for example, has only a 50 cp viscosity at 25° C. Above 35 per cent solids, however, the viscosity increases sharply with increasing solids, attaining a viscosity of over 4,000 cp at 40 per cent solids.

As a result of the lack of a pronounced hydrophile-lipophile balance, the lignosulfonate molecule shows little activity in lowering oil-water interfacial tension. If, as is sometimes done, drop number determinations were made as the criterion of an emulsifying action,[7] the lignosulfonate solutions would be rated only slightly better than distilled water and not at all comparable with an emulsifier such as sodium oleate.

It was pointed out years ago, however, that emulsifiability implies two factors: (a) ease of emulsification and (b) stability of the resulting emulsion. Drop numbers indicate only the first factor and are not a complete measure of an emulsifier's effectiveness.[8,9]

The effects of water solutions of commercial sodium and calcium lignosulfonates on surface and interfacial tensions are compared with those of the majority of surface active agents in Fig. 1 and Fig. 2.

Determinations of surface and interfacial tensions were made by the

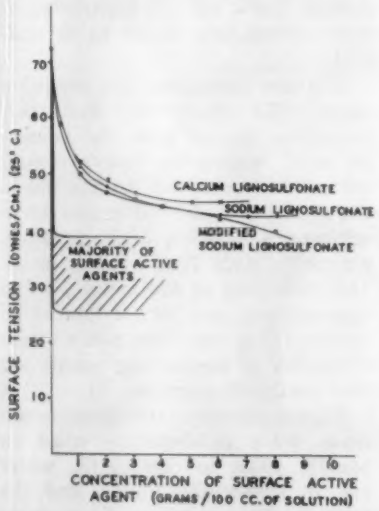


Fig. 1 — Surface tension of lignosulfonate solutions.

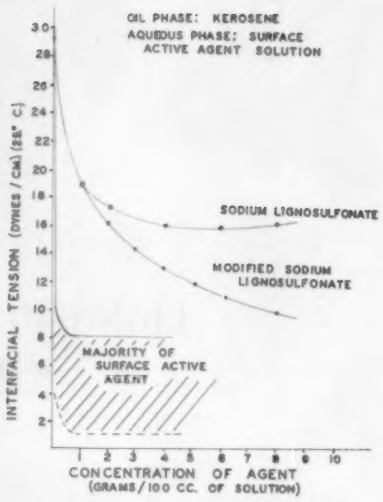


Fig. 2 — Interfacial tension of lignosulfonate solutions against kerosene.

ring method using a Christian Becker interfacial tension balance. Treatment of data followed the recommendations of Harkins and Jordan,[10] Zuidema and Waters,[11] and Zuidema and Pilz.[12] Actual experimental techniques followed ASTM Method D-971-48T, except that in the determination of interfacial tension the interface was allowed to age five minutes instead of 30 seconds to attain sorption effects.

The time lag effect[13] in attaining equilibrium at an oil-water interface is quite pronounced with many surface active agents and the lignosulfonates are no exception. For example, with a 1 per cent solution of a modified sodium lignosulfonate against kerosene, the initial interfacial tension value was determined as 14 dynes/cm. When the interface was aged two hours the interfacial tension dropped to 8 dynes/cm.

The modification of an oil-water interface by the presence of lignosulfonate in solution and variation of the interfacial tensions with time show that the lignosulfonate is adsorbed at the oil-water interface. This adsorption and orientation becomes visibly apparent when working with water solutions of sodium lignosulfonate in the determination of interfacial tensions. When the platinum ring of the surface tension balance is withdrawn from the water solution into the oil phase, a tough membrane forms across the ring. If a needle is used to punch a hole in this membrane, the structural forces are so great that the hole remains much as if the membrane were a cellophane film. This membrane may be further

cut with a needle until tatters and streamers of the filament hang from the ring. The membrane has the characteristics of a plastic solid so long as it remains in the oil phase; however, as soon as one tip of the filament touches the interface of the main body of the solution, the whole filament disappears instantaneously. This indicates that the effect in which the membrane appears as a plastic solid is due entirely to orientation of the lignosulfonate in the thin film. Thus in a sense the lignosulfonate may be said to form a film or skin about an oil droplet. But unlike the skins of a typical hydrophilic colloid —the saponins, etc.—which quickly form a permanent three-dimensional structure, the lignosulfonate skins exist only at the interface. The lignosulfonate skins are no doubt polymolecular, but they exist only by virtue of the orientation and polarizability of the lignosulfonate molecule. The characteristics of these skins are modified by the presence of electrolytes and alkalinity.

It is well known that the surface activity of ionizable surface active agents is affected by the presence of electrolytes in solution.[14, 15, 16] This effect is ascribed to the lowering of forces of repulsion between the surface active ions. Consequently, more ions of the surface active agent can be packed into the surface film, causing a lowering of the surface tension of the solution.

Adjustment of pH with sodium hydroxide lowers the interfacial tension of a 6 per cent sodium lignosulfonate solution in a 10 per cent sodium chloride solution against kerosene from 15 dynes/cm at 6.5

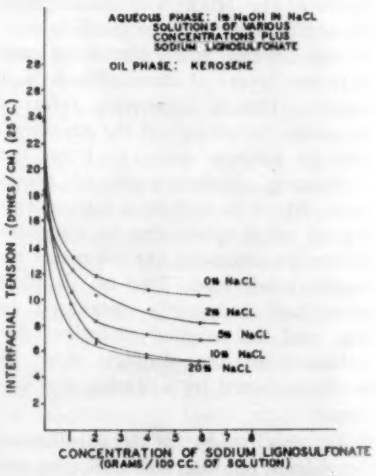


Fig. 3—Interfacial tension of sodium lignosulfonate solution in alkaline sodium chloride solutions.

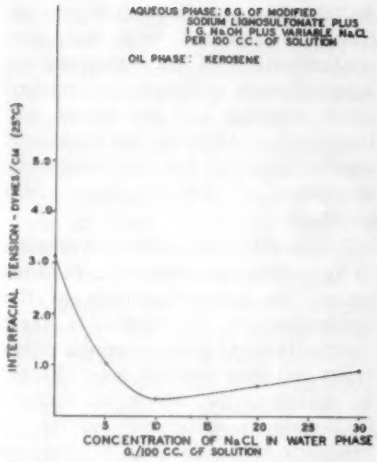


Fig. 4—Interfacial tension of modified sodium lignosulfonate solutions in alkaline sodium chloride solutions.

pH to 6 dynes/cm at 10 pH. The effect of varying the sodium chloride concentration in a 1 per cent sodium hydroxide solution on the interfacial tension of sodium lignosulfonate solutions against kerosene is given in Fig. 3. The effect of varying sodium chloride content on a solution of a modified lignosulfonate is shown in Fig. 4. It is interesting to note that by the ring method a 6 per cent alkaline solution of this modified lignosulfonate, which has been found useful as an emulsifier in brine muds, gives as low an interfacial tension in strong brines as sodium oleate in distilled water.

The addition of calcium hydroxide has little effect upon the interfacial tension of alkaline calcium lignosulfonate solutions, the interfacial tension remaining at about 14 dynes/cm at 25° C. This is undoubtedly due to repression of dissociation of the calcium hydroxide by the presence of highly dissociated sodium hydroxide, for the presence of calcium ion in solution actively drives the lignosulfonate to the oil-water interface forming a tough film.

The general increase in activity of lignosulfonates in the presence of electrolytes makes them useful surface active agents in solutions of high electrolyte content.

Emulsions Stabilized by Lignosulfonates

The stabilization of emulsions by lignosulfonates may be regarded as a result of the adsorption of the lignosulfonate at the interface to establish (a) an electrokinetic charge and (b) a semi-rigid film.

Lignosulfonates in solution do not possess the hydrophilic molecular structure or propensity for micelle formation of the McBain colloidal electrolyte. They have absolutely no solubility in nonpolar liquids and little or no solubility in most polar organic liquids.

Solid lignosulfonates are wetted by oils and in solution are adsorbed at the oil-water interface. The adsorption isotherm of a sodium lignosulfonate is given in Fig. 5 and is compared with the adsorption of sodium oleate. The curves indicate the actual adsorption of lignosulfonate at an immiscible liquid-water-interface and that considerably higher weight percentages of lignosulfonate are required to attain adsorption equilibrium than is the case for sodium oleate. This is most probably due to the greater molecular weight of the lignosulfonate.

The fact that the concentration of lignosulfonate in the dispersion medium is decreased markedly whereas the interfacial tension lowering effect is not pronounced indicates that the lignosulfonate is not migrating into the interface to any significant degree and is being sorbed at the interface rather than in it. This is also indicated by the desorption that occurs when any polar-nonpolar surface active agent is added to the lignosulfonate stabilized emulsions. The active migration of the hydrophobic portion of a molecule of a colloidal electrolyte surface active agent into the oil phase actively displaces the lignosulfonate from the vicinity of the interface.

In aqueous media not containing other surface active agents, increas-

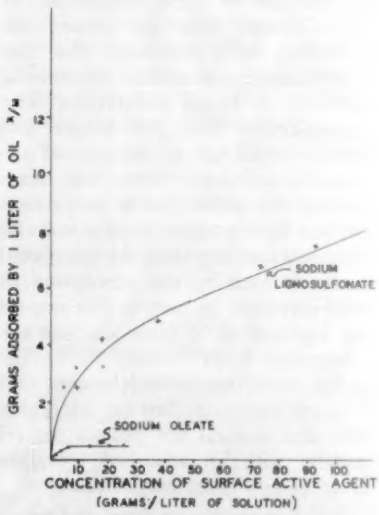


Fig. 5 — Adsorption isotherm of sodium lignosulfonate on carbon tetrachloride.

ing the lignosulfonate concentration drives more lignosulfonate into the interface by mass action effect, resulting in some lowering of the interfacial tension. Increasing the concentration of inorganic electrolyte decreases the charge effect of the lignosulfonate so that the molecules may be packed closer together at the interface, thus lowering the interfacial tension still more. Increasing the electrolyte concentration in addition to lowering the ionization of the lignosulfonate acts also to decrease the solubility of the lignosulfonate in the water phase and thus further increases the pressure driving the lignosulfonate into the interface.

Lignosulfonates are dissociated in water and the molecules are highly charged by hydrolytic dissociation. This charge effect is considerably stronger than that associated with the usual double layer effect. For example, a few milliequivalents of electrolytes will reduce the zeta potential of the usual hydrophobic or hydrophilic colloid to zero, but we have found that one equivalent of electrolyte is necessary to reduce to zero the zeta potential of lignosulfonate as determined by measurement of the electroviscous effect of lignosulfonate solutions.

We believe that adsorption of the lignosulfonate at the oil-water interface of the emulsion droplet acts to create the conditions existing at the interface of a lignosulfonate molecule in water and thus makes possible the development of a greater zeta potential than is possible with the usual surface active agent.

In addition to the electrical effects contributed by the lignosulfonates, the sorption of these compounds at the oil-water interface causes the formation of a semi-rigid film that contributes considerable mechanical stability to these emulsions. The lignosulfonate films grow thicker and stronger with age as the rate of adsorption is rather slow. The films formed are more flexible and coherent and have greater mechanical and chemical stability than the interfacial layers formed by the adsorption of solid powders. In fact, in this respect the lignosulfonate films are like the adsorption films formed by hydrophilic protective colloids except that the lignosulfonate films are not highly hydrated and do not protect the oil droplet with an adsorbed solvation layer of any great magnitude.

If a lignosulfonate stabilized emulsion is contaminated with an inorganic salt the double layer effect is decreased as the electrolyte concentration is increased. With increasing contamination of the emulsion the lignosulfonate molecules are packed closer together and are forced into the interface, lowering the interfacial tension initially, but increasing the toughness of the interfacial film eventually.

The addition of sodium hydroxide to lignosulfonate solutions acts to increase the surface activity of the lignosulfonates by increasing their inherently slight polar-nonpolar properties and their electrokinetic charge. In addition, the action of sodium hydroxide is sufficiently strong to maintain the solubility of sodium lignosulfonate in saturated sodium chloride. Therefore, with sodium hydroxide present the lignosulfonates may continue to act as completely effective dispersing agents in saturated sodium chloride solutions. The solubilizing effect of sodium hydroxide on lignosulfonates in pure water or low electrolyte concentration may, however, impair the skin-forming property of the lignosulfonates, therefore decreasing emulsion stability.

The combination of the highly effective electrokinetic charge effect achieved by the lignosulfonates coupled with the formation of a tough but flexible and coherent skin at the interface explains why lignosulfonate stabilized emulsions are unusually resistant to mechanical handling and chemical contamination.

Preparation of Lignosulfonate Stabilized Emulsions

Because in general the lignosulfonates do not actively lower interfacial tension, efficient mechanical methods must be employed to disrupt the oil phase into droplets. In the case of the preparation of emulsion muds wherein lignosulfonates are used as emulsifiers, addition of the oil to the intake of the mud pumps and the subsequent mechanical action in the hole is all that is needed to obtain an effective emulsion.

Emulsions are obtained with ease with lignosulfonate concentrations ranging between 0.5 and 25 per cent in the water phase and with oil concentrations up to 75 per cent or more by weight. It should be remembered that a solution pressure has to be developed by the lignosulfonate to force it into the oil interface. As has been shown, relatively higher concentrations of lignosulfonate must be employed to form emulsions than is the case with conventional emulsifiers. If an insufficient amount of lignin is present to cover the oil interface a failure to achieve emulsification will result. Some of these failures appear much on the order of an inverted emulsion, but addition of the proper amount of lignosulfonate will convert these poor and partial emulsions into stable oil-in-water systems.

Usually no difficulty will be found in attempts to prepare emulsions of 30 per cent or more oil by weight if 5 per cent lignosulfonate on the weight of the oil is used. Emulsification is commonly regarded as a fairly specific matter—that is, particular emulsifiers are used with certain oils and an emulsifier that is effective with one oil is not necessarily effective with another. Lignosulfonates seem to be effective in stabilizing almost any type of immiscible liquid in water and always give an oil-in-water type emulsion. Lignosulfonates have been used to stabilize oil-in-water type emulsions of hexane, kerosene, diesel oil, lube oil, rubber plasticizing oils, paraffin, benzene, nitrobenzene, turpentine, raw linseed oil, castor oil, carbon tetrachloride, ethlyene dichloride, DDT, chlordane, etc.

Properties of Lignosulfonate Stabilized Emulsions

The most important property of any emulsion system is its stability. The stability of an emulsion system is the ability of the system to maintain the state of the subdivision of the disperse phase. The loss of this ability is evidenced by the coalescence of the droplets of the disperse phase. The growth in particle size of the disperse phase continues until only two layers of immiscible liquids remain. This is commonly referred to as the "breaking" of the emulsion. This is entirely different from the "creaming" phenomenon of emulsions which is merely a concentrating of oil droplets due to sedimentation. In creaming the oil phase remains subdivided. The oil droplets have not necessarily increased in size and the original statistical distribution of the droplets may be easily regained by agitating the system.

In this study of lignosulfonate emulsions, considerable difficulty was encountered at first in trying to evaluate their stability for the simple reason that the customary means of

evaluating emulsion stability did not apply.[17] After investigating the various methods of defining emulsion stability in a quantitative way, a size frequency technique[18, 19] deemed satisfactory was finally decided upon. This involves the measurement of increase in droplet size with time as indicative of stability.

Using the size frequency technique, the tests showed that interfacial tension lowering effect of sodium hydroxide was not sufficient to cause any significant decrease in the average particle size of the emulsion. In low lignosulfonate concentrations the lowering of or decrease in film properties of the lignosulfonate by the sodium hydroxide may contribute to an over-all lowering of emulsion stability. Thus, for the majority of oils the use of sodium hydroxide is not indicated as necessary or even desirable in electrolyte free solutions. Lignosulfonate stabilized emulsions remain stable, however, under extreme pH variation even though some coarsening of the emulsion may occur.

Tests showed that the lignosulfonates will stabilize emulsions very effectively in the presence of electrolytes. Ordinary hard waters, alkali waters, or even sea water may be used to prepare emulsions. Sodium sulfate, aluminum sulfate, sodium chloride, calcium chloride, calcium sulfate, and other electrolytes are virtually without detrimental effect on the stability of sodium lignosulfonate stabilized emulsions.

Mechanical jarring or vibration of ordinary frequencies apparently has no effect on lignosulfonate stabilized emulsions. Mechanical effects such as pumping and jetting are also without detrimental effect. In fact the more the emulsions are worked and the harder they are worked, the better they become.

Lignosulfonate stabilized emulsions are unaffected by phase volume ratio. Here again because of their insolubility in the oil phase, the lignosulfonates stabilize only oil-in-water emulsions and the oil phase may be increased in concentration until the emulsion becomes too thick to handle. There appears to be no tendency for such systems to invert. With high oil concentrations, the viscosity of lignosulfonate stabilized emulsions is considerably lower than similar emulsions stabilized with gums or soaps.

Lignosulfonate stabilized emulsions of high or low oil content may be readily diluted with large volumes of water. Small quantities of highly concentrated emulsions may be added to large quantities of water without destabilizing the emulsion. Apparently the adsorption of the lignosulfonate at the oil-water interface is largely irreversible. This means that the low oil content emulsions are most effectively prepared by first making a high concentration masterbatch and then diluting.

Although the lignosulfonates are not as bad foamers as are the soap-type emulsifiers, it sometimes becomes desirable to treat lignosulfonate stabilized emulsions to remove foam. It is advisable in such cases to use a non-surface active type of antifoam agent such as capryl alcohol. Considerable care should be used in the selection of antifoams for surface active antifoams such as sulfonated oil types may displace the lignosulfonate from the oil-water interface and render the emulsion susceptible to the action of electrolytic contaminants.

For a like reason the addition of soaps or conventional surface active agents is not recommended for use with the lignosulfonates. These agents supplant the lignosulfonate at the interface and the emulsion no longer can be classified as stabilized by the lignosulfonate. If interfacial tension lowering is desired as well as the general characteristics of a lignosulfonate stabilized system, the system should be adjusted with inorganic electrolytes to achieve the desired results.

The lignosulfonates are compatible with hydrophilic thickeners and gelling agents such as CMC, starch, gums, and clays. Lignosulfonate emulsions are adversely affected by some dyes; i.e., basic dyes that react chemically with the lignins as well as those dyes avidly adsorbed at the oil-water interface.

It is sometimes desirable when dealing with emulsions to be able to break them when desired. The stability of lignosulfonate stabilized emulsions is such that conventional procedures do not work too well. The most effective way is to add a cationic surface active agent that will react with and nullify the action of the lignosulfonates. Small amounts of the quaternary ammonium compounds are particularly effective in this respect.

Application to Oil Well Drilling

Lignosulfonate stabilized emulsions in drilling muds have established themselves in field use. In preparing emulsion fluids, attention should be directed toward the properties of the emulsifiers, for the characteristics of the mud are fundamentally dependent upon it. In many field muds the only effective emulsifier present is the deflocculated colloidal clay, for the mud treating complex phosphates are not emulsifiers in themselves nor are caustic quebracho solutions. Mere stabilization of an emulsion, however, is not enough to guarantee fluid loss control as is shown in Table 1. To achieve low filter loss characteristics definite steps must be taken to strengthen the interfacial film to enable it to resist deformation. Care must be taken, however, in the overall treatment to insure deflocculation of the mud solids. A flocculated mud acts as a filter aid to increase water loss as well as increase viscosity and gel values.

It is recognized that mere addition of oil will not make a good mud out of a poor mud, but rather make a better mud out of the good mud. The usual practice in developing emulsion muds is to first form a good drilling mud and then add oil to it. It is not the purpose of this paper, however, to discuss current so called emulsion muds, but to indicate properties of the lignosulfonates that may prove of value in developing new drilling fluids.

The control of fluid loss independent of viscosity and of solids offers intriguing possibilities in the formation of special purpose drilling fluids. With lignosulfonate stabilized emul-

TABLE 1 — WATER LOSS PROPERTIES OF OIL-IN-WATER EMULSIONS

Emulsifier	Concentration (lb/100 lb water)	API—30 Min Water Loss, cc: Fresh Water	API—30 Min Water Loss, cc: Lime Base (2 lb lime/100 lb water)
Sodium lignosulfonate	0	No control	No control
Sodium lignosulfonate	1.0	No control	25
Sodium lignosulfonate	2.0	No control	8.1
Sodium lignosulfonate	4.0	50 (at 6 min)	3.6
Sodium lignosulfonate	6.0	43	2.7
Sodium lignosulfonate	8.0	26.5	2.2
Sodium lignosulfonate	10.0	21.0	2.9
Quebracho	3.0}	No control	45.4
Sodium hydroxide	1.5}		
Emulsifiable oil	(9 gal/bbl of water)	No control	50.0

sions it is possible to formulate emulsion fluids to control water loss with little or no clay content. Such emulsions, we have found, will control fluid loss through sand layers or through the conventional filter paper used in the standard API equipment. Because of the specific properties of lignosulfonate stabilized emulsion, the possibility exists of first forming the emulsion and of using that as the fluid-loss control base to which may be added other ingredients to achieve the desired viscosity, gels, or weight.

If low solids oil-in-water emulsions are thought of as a drilling fluid type, then with the lignosulfonate stabilizers we may consider lime-base emulsions, soda-base emulsions, and emulsions based on saturated salt water.

Lime-Base Emulsions

To convert the conventional lignosulfonate lime-base or lime-treated muds to an emulsion mud, it is only necessary to add oil. The calcium lignosulfonate used as a mud conditioning chemical is present in sufficient concentration to act as an efficient emulsion stabilizer.

Emulsion muds of this sort will be found to have lower water loss than the original lime base, but such muds usually depend upon the wall building characteristics of the deflocculated clay solids as the primary means of securing water loss control and are not what is meant in this paper by the term "lime-base emulsion."

In Table 1 is given the effect of varying concentrations of sodium lignosulfonate in fresh water and when converted to lime-base emulsions. The effect of lime in modifying the characteristics of the lignosulfonate film at the oil-water interface is clearly evident as is the necessity of maintaining a relatively high lignosulfonate concentration in the aqueous phase. Treatment in pounds per barrel of mud is thus dependent on the amount of free water available per barrel of drilling fluid. The free water per barrel of course decreases with increasing solids, water of hydration of clays, starches, and gums. It should be noted that water loss control can be achieved without the addition of any clays or viscosity-increasing gums or starches. We have found in every instance wherein we have tested the water loss of systems containing no clay that the addition of oil to form an oil-in-water emulsion significantly lowered the water loss over that obtained with the base fluid alone. This we have taken to indicate that oil-in-water emulsions in themselves can directly control fluid loss. In our work we have not considered an emulsion system to be stabilized if an unemulsified oil layer appeared in the filtrate. The data presented in Table 1 and in all the following are test values obtained in our laboratories using standard API procedures.

TABLE 2 — EFFECT OF OIL CONCENTRATION ON THE PROPERTIES OF LIGNOSULFONATE EMULSIONS

Treatment: 6 per cent calcium lignosulfonate in the water

Diesel oil, gal/bbl of water	5.8	13.1	22.9	35	52.5
Properties					
Viscosity, cp	2	2	2	4	12
Gels, gm	0-0	0-0	0-0	0-0	0-0
30 min water loss, cc	20.8	24.4	20.0	29.0	27.8
Converted to Lime Base — 2 Per Cent Lime in Water					
Viscosity, cp	2	2	3	16	129
Gels, gm	0-0	0-0	0-0	0-0	0-5
30 min water loss, cc	3.3	2.8	2.8	2.2	2.4

A wide range of oil content will give water loss control with lignosulfonate emulsifiers in lime-base emulsions as is shown in Table 2. This gives considerable flexibility in weight adjustment of the base fluid.

If a low weight drilling fluid is desired, fluids containing 40 per cent or more oil in the fluid phase may be prepared weighing 7.6 lb/gal or less. The properties of such a fluid are given in Table 3.

The presence of clays usually reduces the fluid loss of a lime-base emulsion. It is possible to convert a low solids mud to a lime-base emulsion mud and obtain a low weight, low viscosity, low gel, low water loss, low mud-making fluid. Such a fluid is as resistant to contamination and to temperature as a lime-treated mud, but has lower water loss values—particularly after exposure to temperature. The properties of a low solids, Texas field mud converted to a lime-base emulsion are given in Table 4.

Soda-Base Emulsions

It is not usually possible to treat lignosulfonate stabilized emulsions to obtain minimum water loss in normal soda-base muds. One-fourth to ½ lb of lignosulfonates per barrel may be used as an economical oil emulsifier in phosphate-treated muds. With a low lignosulfonate treatment some reduction in water loss usually results, but the primary advantage seems to be the result of lubrication by oil droplets. Although the low lignosulfonate treatment aids in the formation and stabilization of oil-in-water emulsions in the phosphate-treated muds, the lignosulfonate film at the oil-water interface is not of sufficient strength to prevent the wetting of steel by the oil at points of intense friction. There may be some question, however, whether the inhibition of balling of drilling bits is primarily due to the interfacial relations of oil and steel or to the interfacial relations of oil and clay.

The effect of a low lignosulfonate treatment on a field mud may be illustrated in the case of a 9.5 lb/gal Old Ocean native mud. The original mud had a 15 cp viscosity, 31-96 gm gels, and a 19.5 cc water loss. When treated with 0.2 lb of sodium acid pyrophosphate and 3.4 gal/bbl of diesel oil, the API values were: viscosity, 3 cp; gels, 0-0; water loss, 13.9 cc. Addition of 0.5 lb of sodium lignosulfonate did not effect viscosity or gels and reduced the water loss to 8.8 cc. With the addition of the sodium lignosulfonate, oil no longer separated from the mud on standing and no oil appeared in the water loss filtrate.

Brine-Base Emulsions

A sodium lignosulfonate properly modified will readily emulsify oil in saturated brine. One to 3 lb/bbl of this modified sodium lignosulfonate

TABLE 3 — PROPERTIES OF LIGNOSULFONATE STABILIZED EMULSIONS

Oil Content: 35 gal diesel oil/bbl of water
Emulsion Weight: 7.6 lb/gal

Treatment			Lb/100 lb of Water		
Calcium lignosulfonate	6	6	8	3	3
Lime hydrate	0	0	2	0	2
Bentonite	0	2	2	0	0
Properties					
Viscosity, cp	6	6	12	4.5	15
Gels, gm	0-0	0-0	0-0	0-0	0-0
30 min water loss, cc	24.5	3.0	1.2	45	4.5

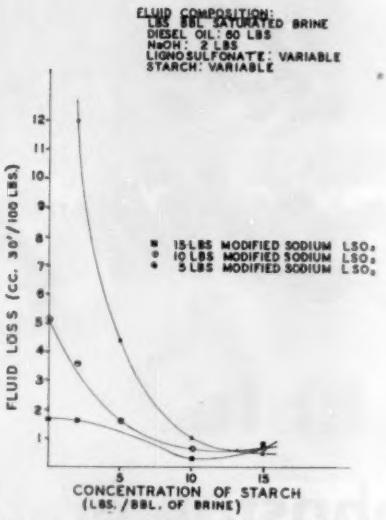


Fig. 6—Effect of starch treatment on fluid loss of brine emulsions stabilized with modified sodium lignosulfonate.

will not only stabilize oil-in-water emulsions in salt contaminated muds but will also act as a clay deflocculent.

Although all the lignosulfonates are able to stabilize oil-in-water emulsions in the presence of sodium chloride and other electrolytes, they vary considerably in their ability to develop fluid loss characteristics. An emulsion system of 7 gal/bbl of diesel oil of saturated salt water treated with 2 lb of sodium hydroxide and 15 lb of calcium lignosulfonate had a 30 minute water loss of 31 cc; the same emulsion system stabilized with a modified sodium lignosulfonate has a 0.8 cc loss.

Saturated brines have less tendency to water block than fresh water and have little ability to swell bentonitic clays. Because of these and other properties of saturated salt water, it is sometimes desirable to drill with a brine fluid.

With brine-base lignosulfonate stabilized emulsion muds it is possible to prepare a low viscosity, low water loss fluid without the use of clays or starch; i.e., 1 bbl of saturated brine treated with 10 lb sodium lignosulfonate and 8.5 gal of diesel oil has by API tests a 5 cp viscosity and 5 cc water loss.

Sodium lignosulfonate stabilized oil-in-brine emulsions are compatible with starch and such combinations give economical fluid loss control in saturated brines. The fluid loss properties of such combinations are given in Fig. 6.

Non-swelling clays of the kaolin type may be added to the lignosulfonate brine-base emulsion to adjust weight and viscosity. For example, a 11.1 lb saturated brine mud containing 20 per cent by weight of a kaolin clay, with 0.008 per cent sodium hydroxide and 4 per cent modified sodium lignosulfonate in the aqueous phase, was treated with 7 gal/bbl of diesel oil and found to have a viscosity of 18.5 cp, 0-12 gm gels, and 1.9 cc 30 minute water loss.

These brine-base emulsions are quite resistant to heat. For example, an emulsion fluid made by treating with a saturated brine with 10 lb of starch and 5 lb of modified sodium lignosulfonate and 7 gal of diesel oil per barrel of saturated brine was found to give a fluid of 14 cp viscosity, 0-0 gels, and 0.9 cc 30 minute water loss. After pressure cooking at 250° F for 24 hours the same fluid had a viscosity of 9.5 cp, 0-0 gels, and 1.0 cc 30 minute water loss.

Lignosulfonate brine-base emulsions should be considered as a distinct drilling fluid type wherein saturated sodium chloride is deliberately used as the base fluid. Starting with saturated brine, a low water loss sodium lignosulfonate stabilized emulsion is formed to which may be added starch, clays, or weighting agents as desired to adjust properties.

Brine-base emulsions have been found to be of value in workover operations where, because of their stability, they may be reused and moved from job to job. Brine-base emulsions may be of considerable value in drillings adjacent to salt domes through salt stringers and in off-shore operations as well as a completion fluid.

In summation it may be said that application of the unique properties of lignosulfonates may well assist in the design of improved drilling fluids. Emulsion muds and lignosulfonates have proved of value in the field and will continue to prove more valuable as our understanding of their properties and potentialities increase.

TABLE 4 — PROPERTIES OF A LIGNOSULFONATE EMULSION MUD

Base Mud: Old Ocean Native — 19 per cent solids — 9.4 lb/gal

Treatment			Lb/100 lb of Water				
Calcium lignosulfonate	0	0	0	6	6	6	6
Lime hydrate	0	1	0	1	0	1	1
Diesel oil, gal/bbl mud	0	0	32	32	32	32	17
Properties							
Viscosity, cp	17	25	44	73	39	18	8
Gels, gm	35-55	10-20	50-65	120-120	10-15	0-0	0-0
30 min water loss, cc	19.4	140	17.4 (part oil)	90	2.2	0.2	1.1

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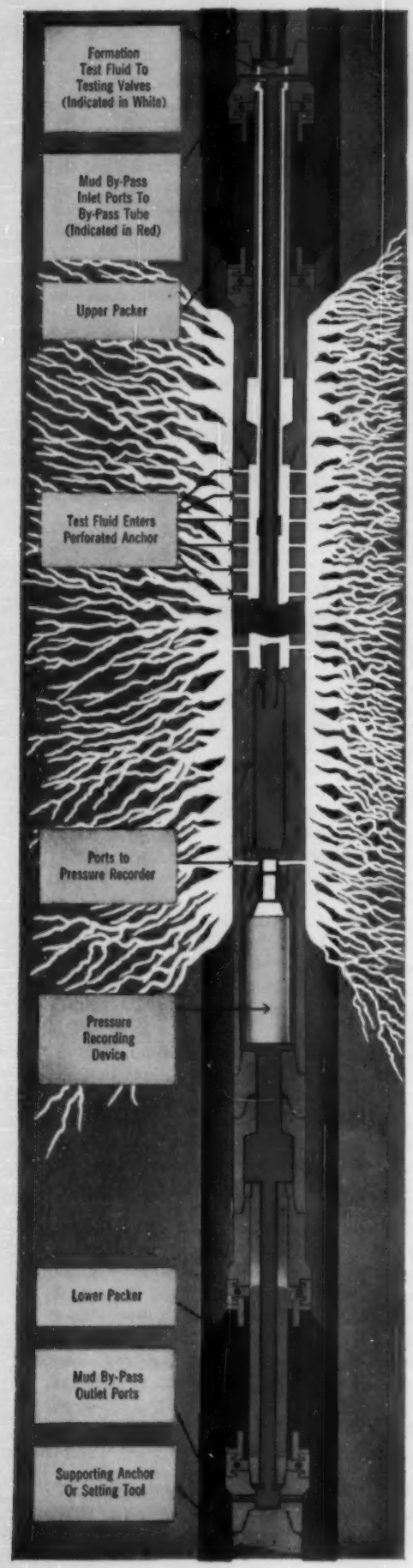

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See how Johnston Straddle Testing with STRADDLE MUD BY-PASS maintains full hydrostatic mud pressure on upper and lower packers—and on all formations below lower packer. Lessens the load on supporting anchor and prevents production from any lower zone in the event of lower packer failure. Should either packer fail, you get an immediate surface indication. Get all these advantages plus ease of running tool into and out of the hole.

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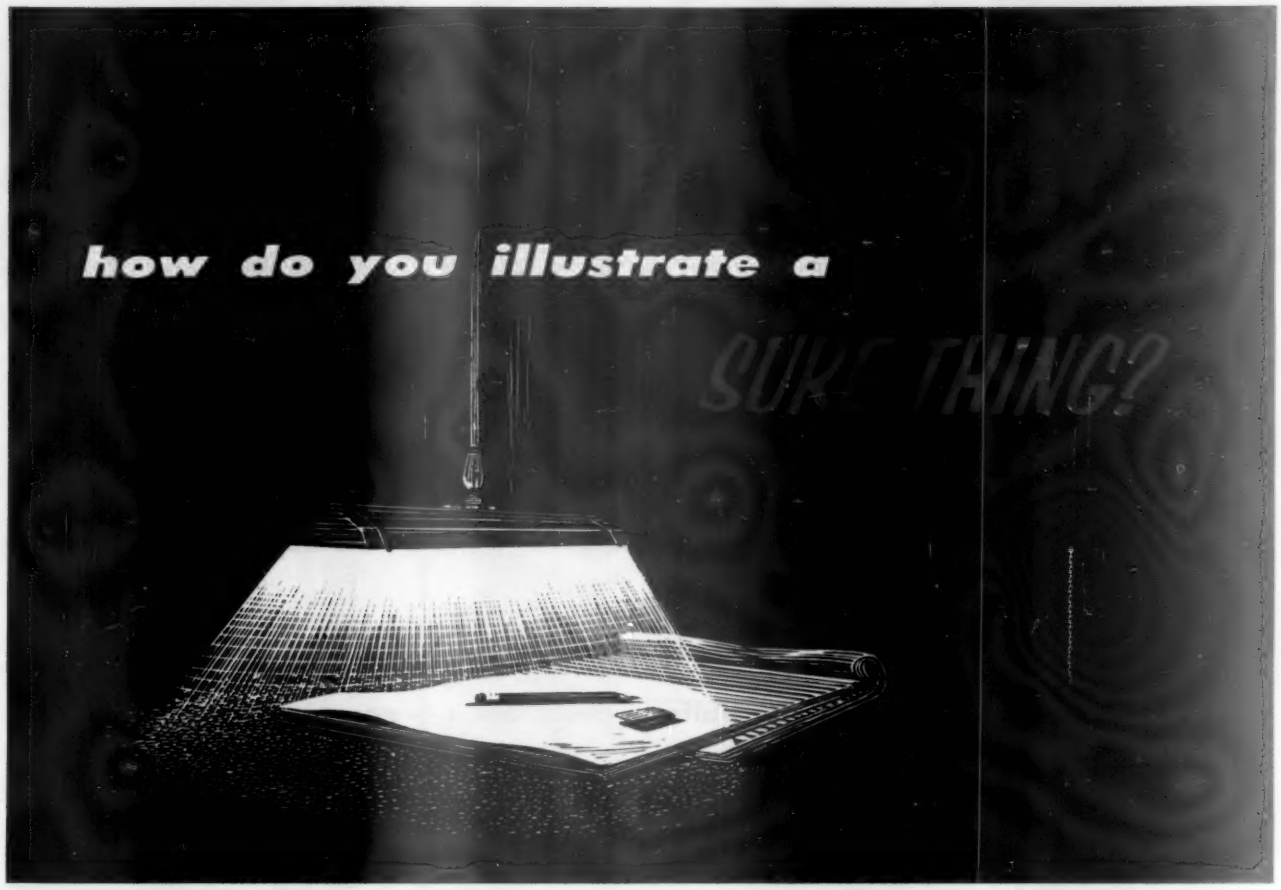

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2. **Deeper and More Uniform Penetration** — more than 10 inches into the formation.
3. **18-Gram Charge** — the largest of any perforator for permanent type well completions!!
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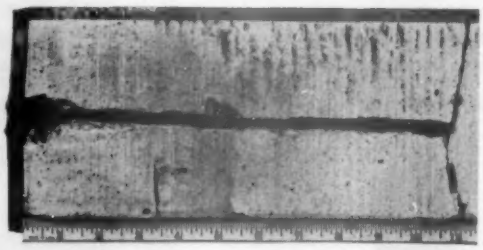
Swing Jet fired *under fluid* into 72-hour aged cement target penetrates ⅜-inch steel plate and almost 11 inches of cement. This is the penetration you'll get in your wells regularly with 18-gram Welex Swing Jet charges.



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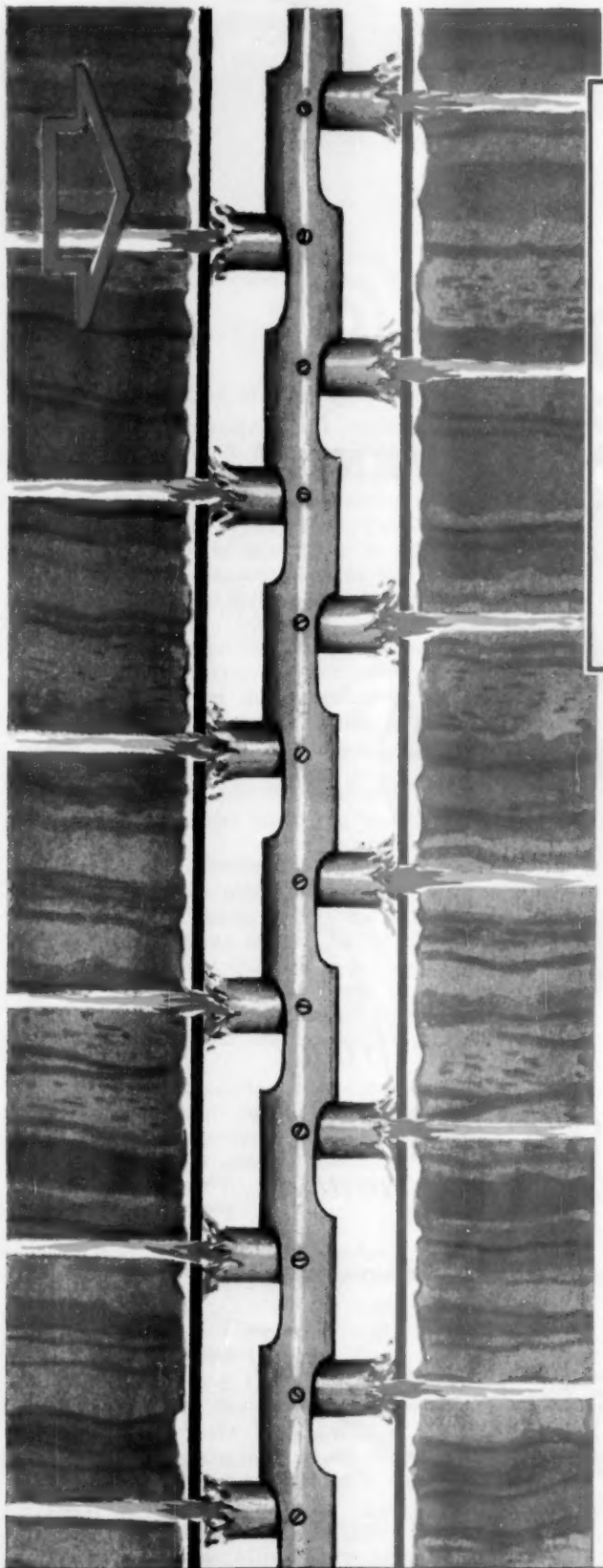

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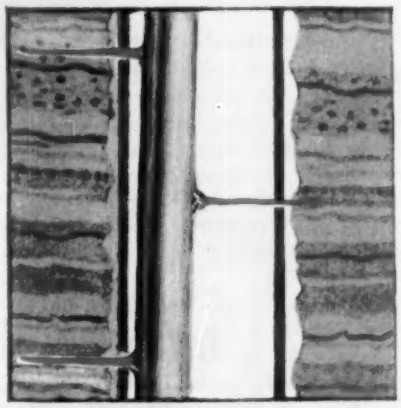
Only the Swing Jet has the snap-open carrier that runs full-power, 18-gram charges through the tubing for permanent-type completions. And, only with Swing Jet will you *consistently* get *½-inch* entrance holes and penetrations of more than *10 inches* into the formation.

Don't be satisfied with LESS than full results from every shot! The Welex Swing Jet has now been fired in more than 1200 wells . . . is the preferred jet for permanent-type completions with major and independent oil producers!



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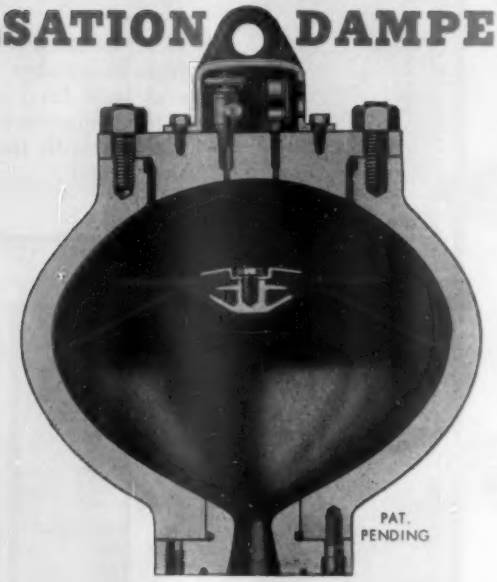

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REPORT and INTERPRETATION

JOE B. ALFORD | EXECUTIVE SECRETARY PETROLEUM BRANCH, AIME

In Appreciation of Harvey S. Mudd

Petroleum members will regret to learn of the death of Harvey S. Mudd, an AIME leader for many years. He died unexpectedly and suddenly as a result of heart failure in the early morning of April 12, 1955, at his home in Beverly Hills, Calif. On the occasion of his death it is appropriate to call attention to his outstanding professional life, as well as the significant contributions which the Mudd family has made to the AIME.

Newer members of the Branch may not recall the leadership of Harvey S. Mudd during his days as director, vice-president, and president of AIME. Undoubtedly all members are acquainted with the contribution made by the Mudd family through the Seeley W. Mudd Fund, established in 1929 in honor of Harvey Mudd's father. It was created by Mrs. Seeley W. Mudd and her sons, Harvey Seeley Mudd and Seeley Greenleaf Mudd.

Seeley W. Mudd Fund

This fund now totals $104,720 and is used to finance publication of books written by AIME members and to distribute books to new Junior Members. *Elements of the Petroleum Industry* is the best-known to Petroleum Branch members of those books sponsored by the "Seeley W. Mudd Series." Six other books have been sponsored in this manner, and others are authorized.

Through the courtesy of the Seeley W. Mudd Fund a new Petroleum Branch Junior Member receives a free copy of *Petroleum Conservation* and *A Professional Guide for Junior Engineers*. New Junior Members of the other Branches receive their choice of other books upon joining.

Appreciation by James L. Bruce

At the time of his death, Harvey S. Mudd was serving as a director of the Seeley W. Mudd Fund Committee. In an appreciation of Harvey Mudd, his good friend, James L. Bruce states:

"He was born in Leadville, Colo., on Aug. 30, 1888, the son of Col. Seeley W. Mudd and Della Murlock Mudd. Col. Mudd was a renowned and highly respected mining engineer whose elevated sense of ethics and professional responsibility is strongly reflected in Harvey's life."

Through Harvey Mudd's energetic leadership as president, Cyprus Mines Corp. became the most important mining activity in the Near East and one of Europe's greatest. The company extended into iron production, and, most recently, into the petroleum and natural gas development, partially through a subsidiary, Cyprus Petroleum Co.

He had outstanding administrative abilities which led to his appointment as trustee and director of many companies. He was also a civic leader in the Los Angeles area.

His Leadership in AIME

It was in 1917 that Harvey Mudd became an AIME member. In 1945 he was AIME president; in 1937 to 1940 and 1943 to 1945 he was vice-president; and in 1928 to 1935, 1940 to 1944, and 1946 to 1948 he was a member of the Board of Directors.

James L. Bruce states: "He was a diligent worker on several important committees . . . on committees, as director, and during his terms as president and vice-president, he gave unsparingly of his time and broad experience in planning programs and procedures for the improvement of the Institute."

Gifted, Friendly Person

"Harvey Mudd was gifted with great talents, logical mentality, and very unusual capacity for useful and persistent work. He loved people and was deeply interested in contributing to their educational and cultural development. As his experience grew, he became still better qualified to extend the usefulness of his services, consequently was surrounded by loyal, loving associates and friends who now suffer great loss and sorrow from his passing."

The Mudd family has made very real contributions to the AIME specifically and to the engineering profession in general. The Petroleum Branch, as well as the rest of the Institute, is surely saddened by the passing of another outstanding member of this family, Harvey S. Mudd.

Harvey S. Mudd

To Maintain Standards

THE BRANCH ADMISSIONS COMMITTEE

VIRGINIA B. DAGGETT

ASSISTANT SECRETARY
PETROLEUM BRANCH, AIME

With the emphasis so often placed on numbers of new membership applications, we may tend to overlook the importance of the procedures necessary to election, and particularly the loyal and conscientious work of the Petroleum Branch Admissions Committee.

Meeting once a month in Dallas, this committee considers every application for admission or reinstatement, to the three professional grades of membership, as well as applications for change of status to Member. Theirs is the responsibility of determining whether each applicant meets the qualifications set forth in the AIME bylaws for the status to which he aspires. The committee's recommendations for election are then forwarded to the AIME Board of Directors for final approval.

The Petroleum Branch Admissions Committee is only in its third year of operation. At its first meeting in Nov., 1952, the committee approved applications for 41 new Members, Associate Members, and Junior Members; 4 reinstatements; and 4 changes of status. In May of this year the corresponding figures were 98, 8, and 10, or more than double those of the first meeting.

Prior to 1952, all applications for AIME membership were considered by the Institute Admissions Committee. Because of the increasing number of applications to be considered each month and the necessarily limited Petroleum Branch representation on the committee, it was decided to inaugurate the auxiliary committee in Dallas for the purpose of screening all Petroleum Branch applications. J. H. Sullivan, The Atlantic Refining Co., served as its first chairman from Nov., 1952, through 1953. F. G. Prutzman of Sun Oil Co. was 1954 chairman.

Present Admissions Committee members are Virgil B. Harris, chairman, San Juan Oil Co.; C. C. Harter, Oil and Gas Property Management, Inc.; Charles H. Hudson, Magnolia Petroleum Co.; Raoul J. Bethancourt, Sun Oil Co.; Oscar K. McElheney, The Atlantic Refining Co.; and Jack Wahl, James A. Lewis Engineering, Inc.

Collectively, this group has long and diverse experience in the engineering profession. Frequently they are personally acquainted with applicants, but naturally they cannot have first-hand information on each name that comes before them. The committee must rely to a large extent on the recommendations of the member endorsers, who confirm by their sponsorship that they consider the candidate eligible for the membership status sought.

It is for the same reason that the list of those "proposed for membership" is published each month in the Journal. As will be noted below, each candidate's name is followed by the grade of membership for which he has applied. It is the privilege and responsibility of all members to give the Admissions Committee the benefit of any knowledge pertinent to the professional qualifications of those applying for membership.

As the Petroleum Branch continues a period of rapid numerical growth, the professional standards associated with AIME membership must be kept in mind. Discriminating endorsement and review of the published names will assist the Admissions Committee in upholding these standards while extending the benefits of membership to as many as possible.

Proposed for Membership, Petroleum Branch, AIME

TOTAL AIME membership on March 31, 1955, was 22,290; in addition 1,762 Student Associates were enrolled.

PETROLEUM BRANCH ADMISSIONS COMMITTEE

Virgil B. Harris, chairman; C. C. Harter; Charles Hudson; Raoul J. Bethancourt; Oscar K. McElheney; Jack Wahl.

INSTITUTE ADMISSIONS COMMITTEE

P. D. Wilson, chairman; F. A. Ayer, A. C. Brinker; R. H. Dickson; T. D. Jones; F. T. Hanson; Sidney Rolle; O. B. J. Fraser; F. T. Sisco; Frank T. Weems; R. L. Ziegfeld; R. B. Caples; F. W. McQuiston, Jr.; Arthur R. Lytle; H. R. Wheeler; L. P. Warrimer; J. H. Scaff.

The Institute desires to extend its privileges to every person to whom it can be of service, but does not desire as members persons who are unqualified. Institute members are urged to review this list as soon as possible and immediately to inform the Secretary's office if names of people are found who are known to be unqualified for AIME membership.

In the following list C/S means change of status; R, reinstatement; M, Member; J, Junior Member; A, Associate Member; S, Student Associate.

California

Bakersfield—Yost, Stewart William (J).
Duarte—Robinson, Ralph Lewis (J).
Long Beach—Pohlmann, Henry Fred (M).
Los Angeles—Snyder, Leonard Milton (J).
Ventura—Rodgers, Thomas Howard (M).
Whittier—Bentson, Harold George (M).

Colorado

Denver—Bodine, Ken Earl (J); Smith, Clarence Edmond (J).

Illinois

Oak Park—Laird, Hubert Charles (M).

Kansas

Florence—Minturn, Benjamin E. (A).
Great Bend—Butler, Weldon Collins (M); Robinson, Joseph L. (A).
Satanta—Robinson, Arthur Haymond (M).
Wichita—Cashen, Robert Frank (M); Cline, Wayne Harold (M).

Louisiana

Metairie—O'Connor, Joe Christopher, Jr. (M).
Shreveport—Russell, Colonel James, Jr. (M).

Massachusetts

Worcester—Horner, Robert Samuel (A).

New Mexico

Eunice—Lannen, Richard Cecil (J).
Hobbs—Curry, James Richard (J).
Monument—Wilson, Robert Brooks (J).
Santa Fe—Rieder, Charles Milford (M).

Oklahoma

Oklahoma City—Hicks, Troy Franklin (J).
Tulsa—Corbitt, James Preston (C/S-A-M); Freeman, Clarence Franklin (M); Glass, Eugene D. (C/S-A-M); Murray, Albert Nelson (M); Pringle, Richard Braden (M); Sturdevant, William Michael (M); Wadman, Arthur William, Jr. (M); Zapf, William Frederick, Jr. (J).

Pennsylvania

Bradford—Bright, Robert Paul (J).

Texas

Ballinger—Allison, Robert Sloan (J).
Beaumont—Kieke, Earl Max (J).
Bellaire—Allen, Joseph Columbus (M); Arendt, Harry Shaw (M); Galloway, Harold Reid (J); Muzacz, Walter Frank (M); Pixler, Bertram Otto (M); Steele, Hansen Hall (M).
Bellville—Duhon, Lamarque Marcellus (R, M).
Corpus Christi—Clary, David Max (J); Long, Fred E. (J); Roberts, Ralph Meredith (M).
Dallas—Kastrop, Julian Edward (R, M).
Fort Worth—Clapham, Eldon Edward (J).
Genoa—Koehler, William Milton (J); Nelson, Norman Allen (J).
Houston—Bagley, James William, Jr. (J); Barron, Oscar Noel (J); Brannon, Hezzie Raymond, Jr. (J); Campbell, John L. P. (M); Christian, Lawrence D. (J); Coolidge, John Wilson (R, J); Elkin, Brudge (J); Ellis, Rudolph V. (A); Fidler, Charles Edward (J); Gaskell, Merwin Harry (J); Hadlow, Robert Edward (J); Hanks, Eugene Huston (J); Harris, Leldon M. (J); Heberling, Harold Keith (J); Kearney, Raymond Warren, Jr. (A); Kunz, John Edward (M); Lawrence, George Howard (J); Le Bleu, Adnell Henry (A); Lemex, Herbert Maurice (M); Miller, Terrell Vorse (M); Mims, Jim W. (J); Monk, James William (M); Moore, Howard Holland (A); Moores, John David (J); Penland, Charles Guy (J); Pounds, Robert L. (J); Rigg, Arthur Melvin (J); Roberts, Fred E., Jr. (J); Sage, Vernon Ray (J); Short, Albert Warren (A); Sterk, Robert Peter (J); Swearingen, William Paul (M); Taylor, Robert Stanley, Jr. (J); Walker, Allison (A).
Irving—Sharp, Lorld Glenn (M).
Kilgore—Johnson, Robert Ernest (J).
Kingsville—Hibbs, Harold Marion (J).
McAllen—Martin, Edgar Estes (M).
Orange—Ross, Rupert D. (M).

Utah

Salt Lake City—Turner, Tom Edward (M).

West Virginia

Ravenswood—Cooper, Charles Edward (J).

Ireland

Belturbet, Co. Cavan—Wilson, Robert Claude (M).

Saudi Arabia

Dhahran—Nelson, Duane Orrin (J).

Venezuela

Maracaibo—Brooke, Edward Albrow (M).

SOUTHERN CALIFORNIA'S ANNUAL FIELD TRIP "SELL OUT" EVENT

PAUL H. JAMISON
MEMBER AIME

KOBE, INC.
HUNTINGTON PARK, CALIF.

Saturday, May 7, members of AIME, Southern California Petroleum Section went down to the sea, 293 strong, to participate in the Section's Annual Field Trip. Every available ticket for the event had been sold five weeks earlier, and on the morning of the trip every ticket holder was on the dock 45 minutes ahead of time.

The reason for the dockside rendezvous, and one reason for the high interest in the trip itself, was the fact that the morning period kicked off with a tour by boat around Monterey Oil Co.'s pioneer offshore drilling island (where more than 60 wells are to be drilled from a 75-ft. circular platform) and a cruise through the Long Beach Harbor.

An unusual requirement for the trip was coats and ties, for the entire group was invited to luncheon at the Navy's swank Officers Club, Allen Center, on the Navy Base at Terminal Island. This pleasant departure from conventional field trip box lunches was sponsored by Naval Petroleum Reserve Co. No. 11-6 with Rear Admiral Harry P. Stolz, USNR and Commander Rolla A. Walling, USNR as hosts.

In the afternoon, there was an on-the-ground swing through the Wilmington field where more than 2,600 wells have been drilled amidst heavy industrial and harbor activities. One of the major problems in the development of the field has been subsidence, which has dictated that extraordinary measures be taken to prevent inundation by harbor waters. Another unusual problem, probably related to subsidence, has been lateral faulting which, in hundreds of instances, has sheared well casings. Methods, procedures, and devices being used to counteract these problems were shown and discussed by representatives of the leading operators of the field, including Long Beach Oil and Development Co., Richfield Oil Corp., and E. B. Hall and Co.

At the conclusion of the trip, the group trekked to Shell Oil Co.'s recreation hall on Signal Hill where beer and barbecue were served by a distinguished group including Dave Caldwell, Paul Andrews, Sam Grinsfelder, Milton Loy, and Lawrence "Snooky" Chamber.

Members of this year's annual Field Trip Committee were Henry G. Abadie (Long Beach Oil Development Co.), chairman; Milan G. Arthur (Union Oil Co.), advisory; W. Anderson (Oil Tool Corp.), food; Paul Jamison (Kobe, Inc.), publicity; Oran Haseltine (Signal Oil & Gas Co.), Junior Section representative; John Casner (Youngstown Steel), tickets; Max Taves (Richfield Oil Corp.), finance; Jack Lynch (Richfield Oil Corp.), caravan scheduling; and George Hilty (Long Beach Oil Development Co.), program.

Adomite

A New Product With Big Possibilities—Continental Oil Co. has developed a new material—Adomite—which can be mixed in crude oil to lower the fluid loss so that the oil can be used as a fracturing fluid. Field tests have shown excellent results and the product has been placed on the market. The Chemical Process Co. distributes Adomite as part of our fracturing services.

When applicable, the use of crude oil rather than refined oil for fracturing offers substantial operating economies in addition to many completion advantages. By simply lowering the fluid loss, Adomite allows usual amounts of sand to be carried in thin crude oil without screening out. Thus without excessive fluid loss, the oil will afford a more extensive fracture. Lower injection rates also are possible, less equipment is required, wells clean up better and faster, and the sale of the oil is not affected.

The chances are that Adomite has an immediate place in the completion work you have under way. If you will write to The Chemical Process Co. in Breckenridge, Texas, or contact one of our many stations in the Mid-Continent area, we'll be glad to tell you more about Adomite and give you descriptive literature without obligation.

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MEET the AUTHORS

JOSEPH G. RICHARDSON is a research engineer with the Production Research Div. of Humble Oil & Refining Co. He joined Humble in 1948 after receiving his BS at Texas A&M College and his SM in chemical engineering from Massachusetts Institute of Technology.

J. D. SUDBURY received his BA, MA, and PhD degrees in physical chemistry from the University of Texas. He has been employed since graduation in 1949 in the Production Research Div., Continental Oil Co., Ponca City. Currently he is group supervisor of the Production Chemistry Group.

FREDERICK M. PERKINS, JR., received his BS and MS degrees in chemical engineering at the University of Florida in 1952. Since this time he has been with the Production Research Div. of Humble Oil & Refining Co. in Houston, Tex.

J. E. LANDERS received his BS degree in chemistry from Southern Methodist University in 1953. He worked for one year as a corrosion engineer in the Production Research Div., Continental Oil Co., Ponca City. He is now serving with the U. S. Army at Fort Bliss in El Paso.

JOSEPH S. OSOBA graduated from The University of Texas in 1942. He received his PhD in physics from Washington University of St. Louis in 1949. Since that time he has been with the Production Research Div. of Humble Oil & Refining Co.

D. A. SHOCK is supervisor of the chemical section of Continental Oil Co.'s Production Research Laboratory. In 1933 he received his BS degree in chemical engineering from Colorado College; and in 1946 he completed study for his MS from the University of Texas in physical chemistry.

(Continued on page 31)

Mid-Continent Section to Pay Membership Dues For Outstanding Petroleum Engineering Students

The Mid-Continent Section has informed the outstanding petroleum engineering student at University of Tulsa and at Oklahoma A&M that it will pay his Junior Membership dues in AIME for the first two years following graduation.

This gesture on the part of the Mid-Continent Section is a further step in its strong student program which was recognized on page 33 of the May, 1955, issue of JOURNAL OF PETROLEUM TECHNOLOGY. The students chosen will also receive a scroll signifying the change in membership status and a lapel emblem of AIME.

Ed Runyan was selected as the recipient of the award at the University of Tulsa by Dean R. L. Langenheim and a committee from the engineering faculty. Joseph E. Newman, Jr., was chosen by Professor R. E. Vann and a committee from the Oklahoma A&M engineering faculty as the recipient at that school.

In selecting the recipients of this outstanding petroleum engineering student award, consideration was given to scholastic achievement, personality, and the part taken by the student in campus activities.

AIME DIRECTORY

A new all-Institute directory was announced in the March issue. Members may obtain a copy of this directory without cost by sending in the coupon which appeared on page 30 in the March, 1955, JOURNAL OF PETROLEUM TECHNOLOGY, or by letter. Please use the coupon if possible. The printing of the directory is completed and it is now being mailed from the New York office.

Graduate Session Planned

A. F. Van Everdingen, chief reservoir engineer for Shell Oil, will lecture five of 15 days which will be devoted to a graduate summer session in reservoir engineering at the University of Texas. The session is entitled "Performance Prediction of Several Reservoir Mechanisms" and will be held from Aug. 26 to Sept. 15.

The course will be sponsored by the Institute of Advanced Engineering of The University of Texas and the Southern Regional Educational Board. Enrollment for the course, which carries a credit of three semester hours, will be limited to 55.

Other principal co-lecturers will be Professors Harry H. Power and E. W. Hough of the Dept. of Petroleum Engineering and Professor W. T. Guy of the Dept. of Mathematics.

To Decide Building Site

The AIME Board of Directors was expected to vote on June 15 on the proposed new building to house the national engineering societies. At the April 13 meeting of the Board, Past President Leo F. Reinartz presented an amplified report of the Committee of Five Presidents, stating in more detail the reasons for the committee recommending a move to Pittsburgh.

Four of the five presidents on the committee had voted in favor of the move to Pittsburgh, with the Civils offering a minority report recommending that decision be deferred. In any case, it is expected that the Annual Meetings of AIME will continue to be held in New York City on even-numbered years.

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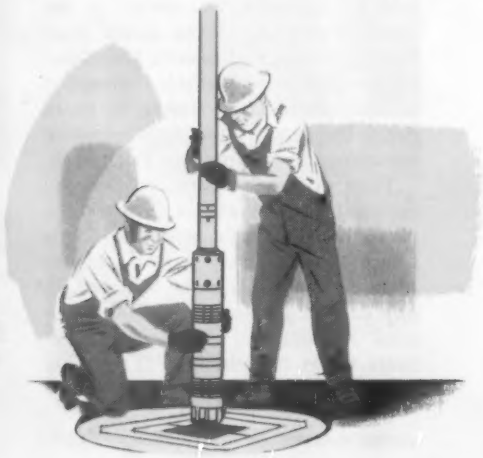
The Western Company

The combined trained personnel of these companies comprises a service organization with over 1,000 men in the field. Nearly 400 service locations ensure maximum availability of Baker Wire Line Bridge Plugs, Packers and Cement Retainers.



3 THESE PRODUCTS

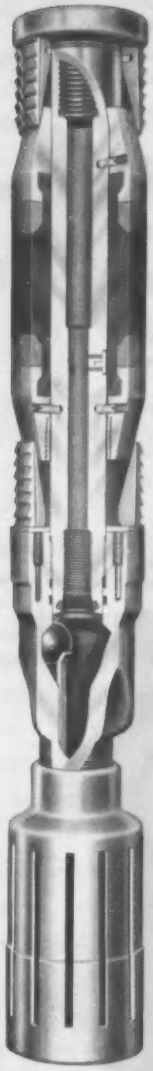
Provide the end result: Superior Performance, Dependability with Maximum Drillability.

BAKER WIRE LINE BRIDGE PLUG
Product No. 400-N

Provides dependable, leak-proof, pack-off even under conditions of extreme pressure and temperature.

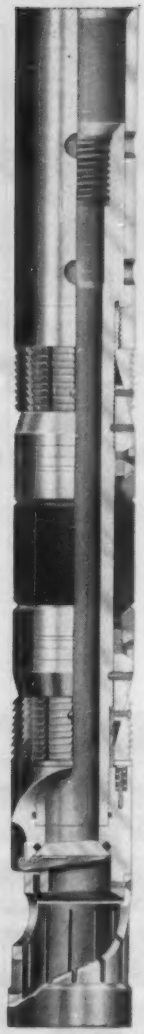
Drills up easily because in addition to being short, it has been especially designed to break up under the action of the bit.

Is immediately available everywhere, in either cast iron or magnesium.



BAKER WIRE LINE CEMENT RETAINER
Product No. 400

Provides the same reliable performance established over the years, plus many new advantages. Try it with the Stinger or Latching Subs for a variety of new applications.



BAKER WIRE LINE RETAINER PRODUCTION PACKER
Product No. 415-D

Provides unsurpassed performance under *any well condition* and a versatility that permits superior application for any production or packer requirement, including:

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SWIVEL JOINTS — Hollow or solid. Swivel knuckle action allows cup to center in tubing, adds life to swab cup by equalizing wear.

OVERLOAD RELIEF VALVE — Prevents stuck swabs by dumping excess fluid when swab is overloaded. Replaces regular swab valve body. Can be field adjusted to recover desired column of fluid. For 2", 2½" or 3" tubing.

ROPE SOCKETS — Plain or swivel, for all rope sizes through ¾". Top half is interchangeable on plain or swivel rope sockets and swivel rope socket joint.

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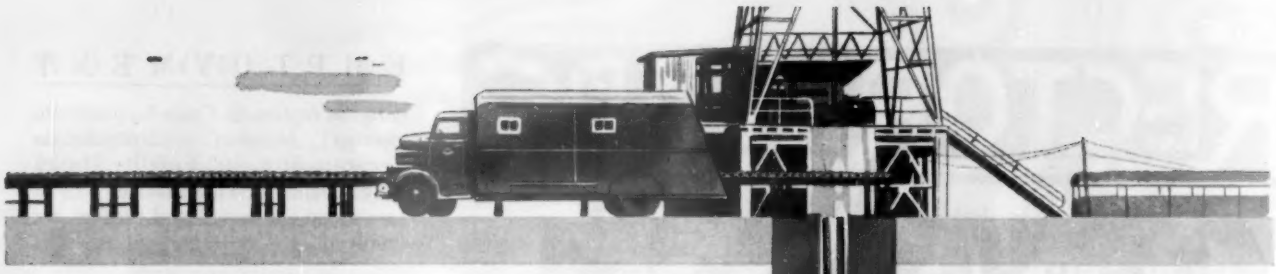

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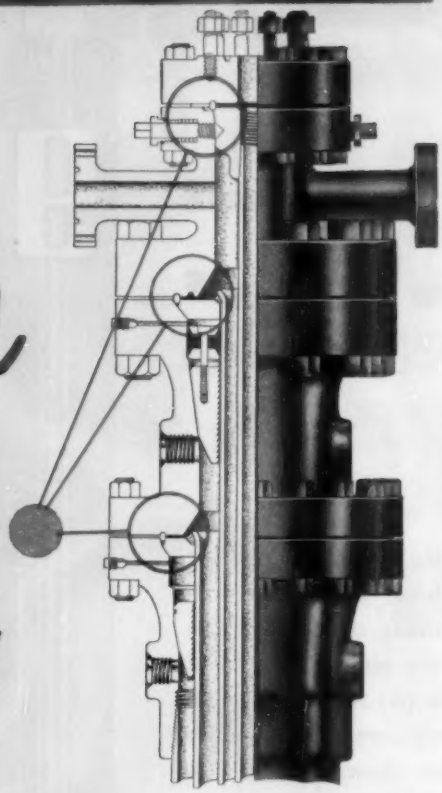

Assembly of Type "RH" Rectorhead Casing Heads with three Casing Strings and Type "M" Tubing Head. Notice how welding ring seats in head body. API Ring Gasket completes the "seal-with-steel."

You wouldn't think of using soft packings between flanges or flanged fittings, particularly where temperatures and pressures are high. Then why use them in casing or tubing heads, where conditions are even more severe, and leaks more disastrous.

When you use Rectorheads you "seal-with-steel." The welded seals, plus API Ring Gasket, never require replacement or maintenance, will not "flow" under high pressure or temperature, will not "freeze" or contract under low temperature, will not burn out or deteriorate. The Rector Welding Procedure is covered in API Std. 6E., Third Edition, January 1952.

Why risk soft seals in your well heads when you don't use them in flanges? Specify Rectorheads and you can "seal-with-steel" between casing strings.

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☆ Petroleum Engineer, 26, completing military service obligation soon. Two years' experience in supervision of drilling, completion, workovers, and general production engineering. Desires position with small company. Now stationed in Houston. Married, one child. Code 248.

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☆ Young man as full-time or part-time laboratory services supervisor. High school education with one or two years of college and business experience. Opportunity to take college

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MEET THE AUTHORS

(Continued from page 24)

T. J. Nowak is a petroleum engineer in the Field Dept. of Union Oil Co., Whittier, Calif. He has been with Union since 1947, and until recently was engaged in research work on well completion practices, production stimulation, and secondary recovery. He holds a BS degree in chemical engineering from the University of Wisconsin.

G. W. Lester received his BS degree in mathematics from the University of Alabama in 1943. He has worked as a petroleum and reservoir engineer for the Union Oil Co. of California since 1948. He is now division reservoir engineer at Santa Paula, Calif.

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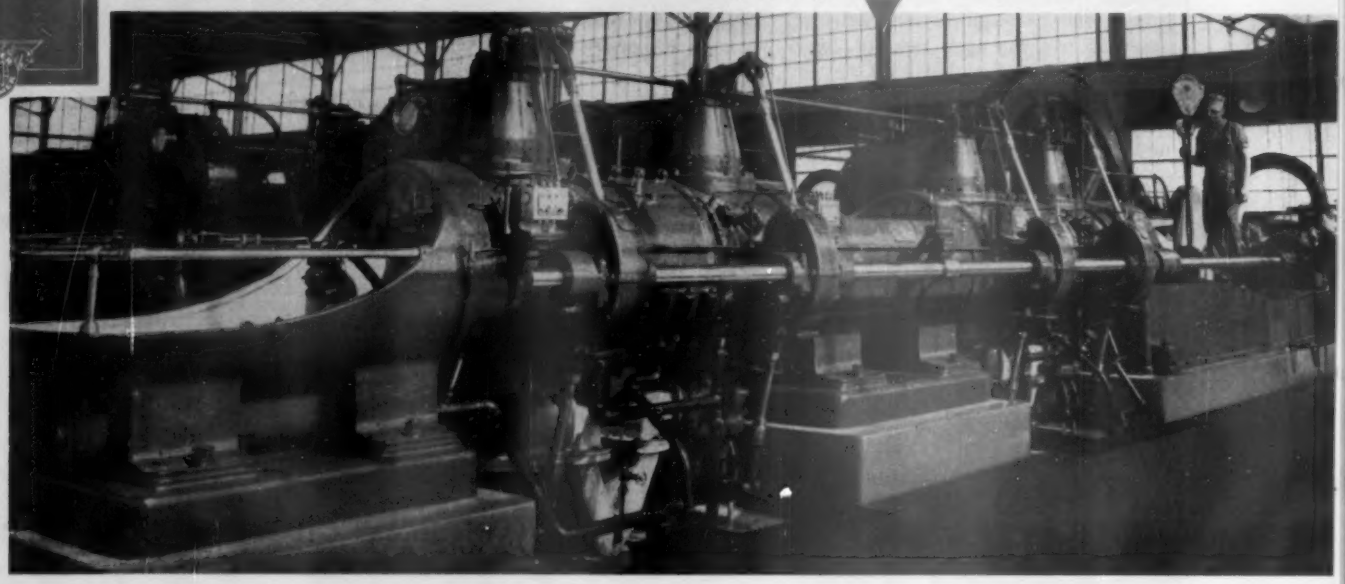
Another Example of Efficient Power at Lower Cost

Line-up of modern 10-cylinder GMV's in the Gwinville, Mississippi, station of the Southern Natural Gas Company. GMV-powered and strategically located at the junction of the main supply line to the east and north, this is the system's key station.

This horizontal Type 22 Cooper-Bessemer twin-tandem unit in the Tarrant, Alabama, compressor station dates back to 1937 when this, then modern, unit was first installed. Today, after 17 years, it continues to operate at top efficiency.



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FOR SOUTHERN NATURAL GAS

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PERSONALS

J. T. SIMON is a new vice-president of Mountain Fuel Supply Co., Rock Springs, Wyo., in charge of the producing and pipeline divisions. The graduate of the University of Tulsa started with Mountain Fuel in 1943 after working for several years with The Ohio Oil Co. In 1945 he became assistant manager of the producing division, the position he held at the time of his selection as vice-president.

☆

E. N. VAN DUZEE has been named production manager for Shell Oil Co.'s Midland, Tex., area. He has been production manager in Shell's New Orleans area since 1946. The former member of the Petroleum Branch Executive Committee joined Shell in 1926 after graduation from the University of Minnesota with the degree of engineer of mines. Upon first joining Shell, then Roxanna Petroleum Corp., Van Duzee spent seven years in West Texas and New Mexico.

☆

S. J. FISHER of Rock Springs, Wyo., has been promoted to the position of senior petroleum engineer for Mountain Fuel Supply Co. He is a graduate of the Colorado School of Mines. He is the program chairman of the Rock Springs Area of the Wyoming Local Section.

☆

Promotion of A. M. SHOOK to division petroleum engineer of the producing department of The Texas Co.'s South Texas Div. has been announced. He succeeds W. F. HERBERT, who was transferred to foreign operations. Shook is a graduate of Texas A&M College and has served as acting division petroleum engineer since last November.

F. H. ALLEN, secretary-treasurer of the Southwest Texas Local Section, has been transferred from Corpus Christi to Oklahoma City by Stanolind Oil and Gas Co. He was district engineer for Stanolind when located in Corpus Christi.

J. E. (HANK) KASTROP has been appointed drilling and production editor for *The Petroleum Engineer* in Dallas. After graduation in petroleum engineering from The University of Texas in 1941, he joined Humble Oil & Refining Co. In 1942 he entered the Navy for four years, then accepted a position on the staff of *The Oil Weekly* in Houston. In 1951 he became production editor for *World Oil*, the position he held until his recent resignation.

A. R. Tullos

P. M. Wilson

A. R. TULLOS has been promoted to division sales manager and placed in charge of a newly-established East Texas-Gulf Coast Sales Div. of Kobe, Inc. P. M. WILSON has been transferred to Houston to this new division headquarters as district sales representative. In separating this area from the former Southern Area Sales Div., J. T. LEWIS has been transferred to Midland as head of the West Texas-New Mexico Sales Div. S. S. MCDONNOLD, recently promoted to district manager, will also be in the Midland office. V. L. O'NEILL, district sales representative, has been transferred to the Fort Worth office from Tulsa. On the West Coast, CARL BROWN, formerly manager of industrial sales in Cleveland, has been named Los Angeles Basin District sales manager for hydraulic sales.

D. M. JACKS has been promoted to the office of vice-president of Visco Products Co., Inc. He attended Mississippi State College and Louisiana State University and has been connected with the oil producing industry since 1937 when he joined Visco. He was made assistant vice-president in Nov., 1954, after serving as junior salesman, district manager, and sales manager. In his new position he will continue to operate as sales manager.

☆

Humble Oil & Refining Co. has announced changes in its Production Dept. supervisory personnel, some of which affect Petroleum Branch members. D. H. WINCHELL has been transferred from the West Texas Div. office to the Louisiana Div. office. L. B. SCHNITZ has been promoted from associate petroleum engineer to petroleum engineer in the Kelsey District, Southwest Texas Div. R. G. TONKIN was made district supervising petroleum engineer of the Stratton District, Southwest Texas Div., having formerly been district petroleum engineer at Greta.

☆

ROBERT K. JAMES is now with Socony Mobil Oil Co. on loan to Iranian Oil Exploration & Producing Co. in Abadan, Iran. He holds the position of senior petroleum engineer. Formerly he was senior petroleum engineer for Magnolia's Gulf Coast Div. office in Houston.

☆

W. A. HENSLEE, of Baroid Div., National Lead Co., has been appointed superintendent with headquarters in Odessa. He has nine years of drilling mud experience with Baroid and will supervise activities of the service engineers in West Texas.

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Louisiana Tech Officers Chosen

Glen Lee Corrigan, professor and head of the department, has accepted the position of faculty sponsor of the Louisiana Polytechnic Institute Student Chapter for the 1955-56 academic year. Officers elected for the coming school year are: Clayton G. Price, president; Charles E. Spruell, vice-president; Conley P. Smith, secretary; and Robert Bass, treasurer.

Necrology

Gustav Egloff, research director of the Universal Oil Products Co. of Des Plaines, Ill., died on April 30 at 69 years of age. He had joined this company in 1915 when it had a small research building in Independence, Kan.

Egloff held 300 patents here and abroad relating to processing of petroleum oil, coal, shale oil, and chemical derivatives of hydrocarbons. He was author of 650 articles, pertaining primarily to the cracking and refining of oil.

Date Elected	Name	Date of Death
1906	O. U. Bradley	Unknown
1940	Harry E. Crum	1955

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Local Section Meeting Schedule

Petroleum Branch records indicate that the men listed below as chairmen are either newly-elected for 1955 or are serving unexpired terms after being elected in 1954. When available, the normal meeting date of each section predominantly petroleum in membership is listed.

The Branch office would appreciate receiving any additions or corrections to this list, so that all chairmen may be listed correctly and normal meeting dates may be published for each local section in future publications.

BILLINGS PETROLEUM SECTION: Meets in Billings, Mont. *Chairman,* Charles F. Hunkins, Northern Pacific Railway, Billings.

DALLAS SECTION: Meets third Monday each month in Dallas. *Chairman,* R. F. Madera, Republic Natural Gas Co., Dallas.

DELTA SECTION: Meets second Tuesday each month in New Orleans. *Chairman,* B. L. Francis, Texas Co., New Orleans.

DENVER PETROLEUM SECTION: *Chairman,* Robert Hoss, Midwest Oil Corp., Denver.

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PETROLEUM TRANSACTIONS

DIFFERENCES in BEHAVIOR of FRESH and AGED EAST TEXAS WOODBINE CORES

J. G. RICHARDSON
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ABSTRACT

Laboratory experiments have shown profound differences in the behavior of so-called "fresh cores" from the East Texas field and of the same cores after extraction with organic solvents. The residual oil saturation remaining after waterflooding fresh cores was appreciably lower than the corresponding saturations after flooding extracted cores. This behavior was also reflected in the water-oil relative permeability-saturation relations, which were more favorable for high oil recovery from the fresh cores.

These differences were evident not only in the amount of residual oil left after water flooding, but also in the saturation water remaining in the core after displacement by oil. Residual water saturation after displacement of water by oil was higher in the fresh cores than in the extracted cores. Capillary pressure-saturation relations were also different for the fresh and extracted cores.

Imbibition experiments indicated that both fresh and extracted East Texas cores imbibed water spontaneously, but the rate of imbibition of water was higher for samples after extraction than it was for fresh core material.

INTRODUCTION

Several years ago a series of waterflooding tests was made in the laboratory on a number of Woodbine core samples from the East Texas field. These samples had been stored in containers open to the air and were extracted with organic solvents before they were subjected to the laboratory tests. After water flooding, the residual saturation of kerosene, which was the oil used in the tests, was found to average about 30 per cent.

This saturation was higher than expected. In investigating the circumstances which might have been responsible for such a high residual oil saturation, attention was given to possible changes in wetting properties of the rock brought about by the procedure employed in extracting the cores. Preliminary results indicated that the explanation for the high residual oil saturation lay in the wetting behavior of the cores, though what effect extraction had on this behavior was not clear. In consequence, the work described in this report was undertaken in an attempt to investigate the mechanism responsible, and to ascertain the actual residual oil saturation to be expected in the reservoir after water flooding. It was soon found that there were profound differences in the behavior of so-called "fresh cores" from the East Texas field and of the same cores after extraction with organic solvents. These differences were evident not only in the amount of residual oil left after water flooding, but also in the saturation of water remaining in the core after displacement by oil.

The complete explanation of this behavior is not yet apparent. The description of work and results described in following sections, therefore, must be considered as an interim report presenting facts which must await additional information before they can be fully interpreted.

Manuscript received in Petroleum Branch office on July 27, 1954. Paper presented at Petroleum Branch Fall Meeting in San Antonio, Oct. 17-20, 1954.

Discussion of this and all following technical papers is invited. Discussion in writing (3 copies) may be sent to the offices of the Journal of Petroleum Technology. Any discussion offered after Dec. 31, 1955, should be in the form of a new paper.

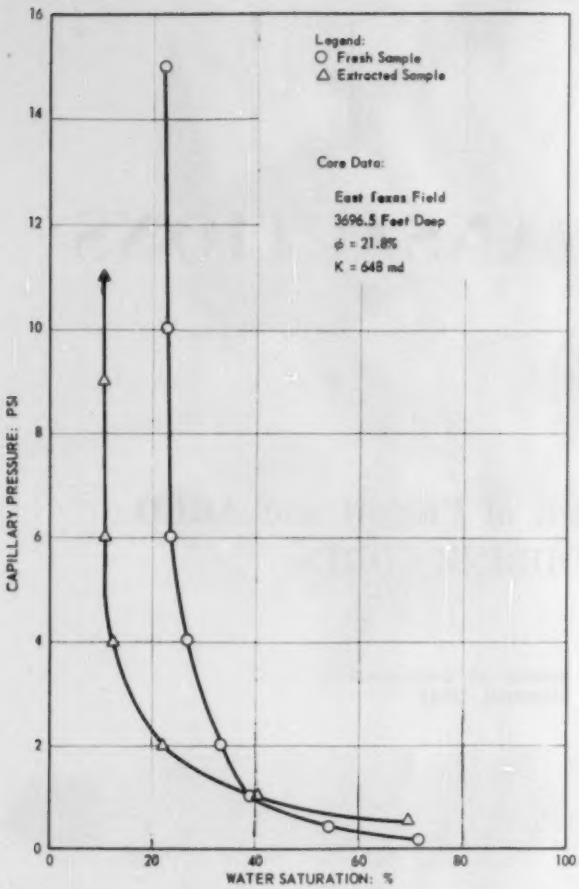

FIG. 1 — COMPARISON OF CENTRIFUGE CAPILLARY PRESSURE-SATURATION RELATIONS OF A FRESH AND EXTRACTED SAMPLE.

CORE SAMPLES USED

All of the core samples used in this study were from the producing zone of the East Texas field. Some were preserved at the wellsite, immediately after they had been removed from the core barrel, to exclude air and to retain the fluid content of the freshly-cut cores. The usual method of preserving cores consisted in wrapping them in aluminum foil and sealing with a thick coating of paraffin wax. These, for convenience, were termed "fresh" cores, even though it is realized that their freshness was a matter of the degree to which they might have been altered by infiltration of water from the drilling mud and by unavoidable exposure to the atmosphere. The term "fresh" was also applied to plugs cut from these cores after they had been transported to the laboratory. Fresh cores, as received in the laboratory, contained some crude oil, some connate water, and some filtrate from the drilling mud used in cutting them.

For comparison with tests on the fresh cores, use was made either of the same cores after extraction with organic solvents, or, in some cases, of cores which were not preserved and which were extracted in the laboratory. These core samples were designated as "aged" cores.

BEHAVIOR AT LOW WATER SATURATIONS

In investigating the differences in behavior of fresh and aged East Texas cores containing water and oil, attention was given to the behavior at low water saturations because of the importance of this region in determining connate water saturation in the reservoir.

The region of low water saturation in both fresh and aged samples was explored by capillary pressure measurements, by displacement of water by oil, by comparison of resistivity measurements, and by measurement of spontaneous water imbibition.

CAPILLARY PRESSURE BEHAVIOR

In examining the behavior of fresh and aged cores in the region of low water saturation by capillary pressure measurements, determinations were first made on fresh cores; the cores were then extracted, and the determinations were repeated. In order to minimize the possibility of anomalous results being introduced by peculiarities of a particular technique, two different methods were used to determine the capillary pressure-saturation relations. These were the centrifuge method and the conventional porous diaphragm technique.

The cores used were from the East Texas field. They were cut with a diamond bit in a watered-out producing zone by use of ordinary mud. The fresh cores, 2¾-in. in diameter, were brought to the laboratory sealed in paraffin, and 1-in diameter plugs were cut parallel to the bedding planes. The plugs were immediately placed in 3 per cent salt water in a closed container, and the system was evacuated to remove any free gas from the plugs.

The plugs were divided into two groups. One group was subjected to capillary pressure measurements by the centrifuge technique and the other by the porous diaphragm procedure. Samples run by the centrifuge method were placed in centrifuge cups filled with kerosene, and were centrifuged in stages down to essentially constant water saturations. Samples run by the porous plate method were placed in capillary pressure cells on porous diaphragms saturated with 3 per cent salt water. The capillary pressure cells were filled with kerosene, and pressure was applied in stages until the complete capillary pressure curve had been obtained.

On completion of these tests, the samples were extracted by alternately flooding with hexane and distilled water. They were then dried and subsequently saturated with a 3 per cent sodium chloride solution. Capillary pressure measurements were then again run on the "aged" samples by the centrifuge and porous diaphragm methods.

Of the 12 samples run by the centrifuge method, most were of low permeability. The average "irreducible minimum" water-saturation of the fresh cores was 45 per cent, and the corresponding value after extraction was 21 per cent. Typical results on one of the more permeable samples run by this method are shown in Fig. 1.

The eight samples examined by the porous diaphragm method were all greater than 1,000 md in permeability. The average terminal water saturation for the fresh samples was slightly more than 9 per cent; the saturation after extraction averaged about 5 per cent. Results typical of those obtained by the porous diaphragm technique are shown in Fig. 2.

Not only were the terminal water saturations greater by both techniques for fresh cores than for the aged samples, but also there were often significant differences in the saturations before the terminal saturation was attained. These differences are particularly evident in Fig. 2, where noticeably higher water saturations

over most of the capillary pressure range were found for the fresh cores.

Residual Water Saturation After Flooding With Oil

In investigating the behavior of fresh and aged cores at low water saturations by displacement of water by oil, use was made of full-size core samples 2¾-in. in diameter. All cores were from watered-out producing zones in the East Texas field and had been cut with ordinary drilling mud.

The fresh cores were removed from their paraffin seals and were cut with a diamond saw into cylinders several inches long. The samples were then placed under kerosene and were evacuated to remove any free gas. Several hundred pore volumes of kerosene were then flowed through the samples under a high pressure differential until no additional interstitial water was displaced. The volume of water displaced from each sample at its terminal water saturation was recorded. The samples were then waterflooded with 20 per cent salt solution to residual oil, then were flooded again with several hundred pore volumes of kerosene to "irreducible minimum" water saturation. This procedure was repeated until four such cycles had been made, at which time the samples were extracted with benzene and methanol, dried, resaturated with brine, and flooded with kerosene until no water appeared in the effluent.

Altogether, nine fresh East Texas samples were subjected to repeated floods. On flooding with large volumes of kerosene for the first time, the average terminal water saturation for these nine samples was

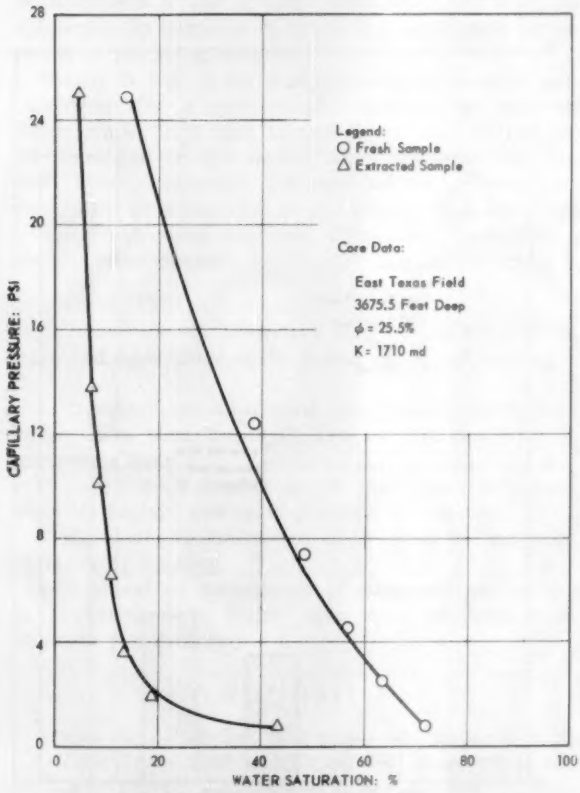

Fig. 2 — Comparison of Porous Diaphragm Capillary Pressure-Saturation Relations of a Fresh and Extracted Sample.

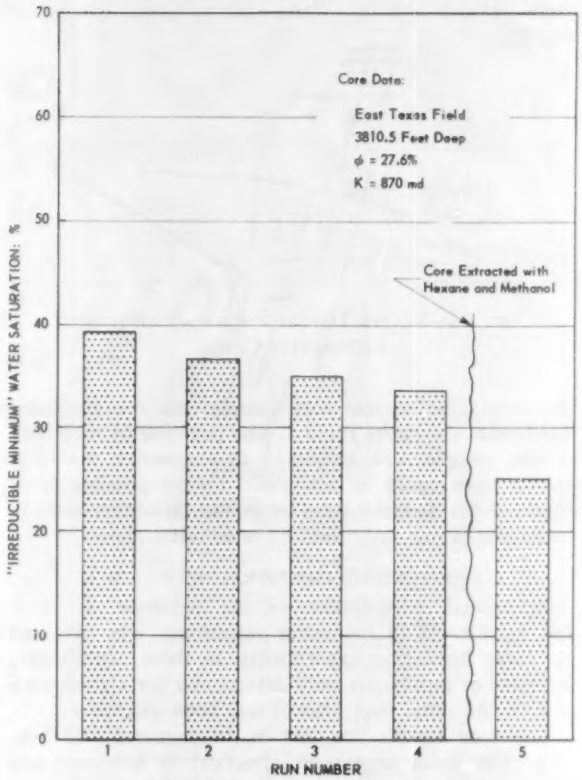

Fig. 3 — "Irreducible Minimum" Water Saturation as Core Was Repeatedly Flooded.

40 per cent. The average water saturation at the end of the second flood was 34 per cent. After extraction of the samples with benzene and methanol, much more of the water could be displaced by kerosene, the average irreducible minimum water saturation being 20 per cent.

The results on a typical sample are shown in Fig. 3, where the irreducible minimum water saturation was 40 per cent when the fresh sample was first kerosene flooded. The corresponding saturation was 25 per cent after the sample had been extracted.

Resistivity Behavior

Resistivity measurements made in conjunction with the foregoing displacement experiments furnished additional information on the behavior of fresh and aged cores. After each cycle in which water was displaced by kerosene, resistivity measurements were made on the core samples by use of conventional techniques.

Since the water saturations were different after each successive displacement by kerosene, it was necessary, in order to facilitate comparison, to correct the resistivities to a common value of water saturation. This was done by making use of the relation $\frac{R_o}{R} = S^n$, where

R_o is the resistivity of the core completely saturated with 20 per cent sodium chloride solution,

R is the resistivity at saturation S of the 20 per cent sodium chloride solution,

n is the saturation exponent, as determined from the experimental data.

All resistivities were corrected by this procedure to a common water saturation of 40 per cent. Typical of

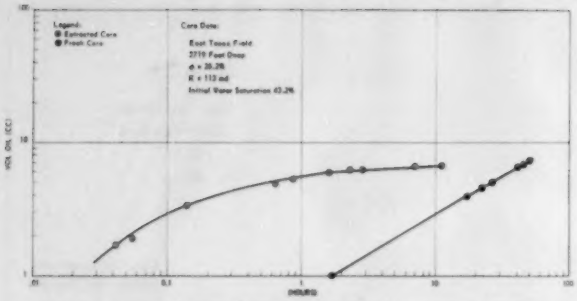

FIG. 4 — WATER IMBIBITION BY A FRESH AND EXTRACTED CORE.

the results for several core samples are the corrected resistivities shown in Table 1. The decrease in resistivity as the sample was subjected to successive floods is greater than could be accounted for by possible error either in the determination or in the procedure used in correcting water saturation to a common basis.

SPONTANEOUS IMBIBITION OF WATER

Additional information on the behavior of fresh and aged cores at low-water saturations was obtained by water imbibition experiments. In these experiments the rates of imbibition were determined for a fresh core and on the same core after it had been extracted.

The core sample was 2⅛-in. in diameter and 3-in. long. The fresh core was immersed in kerosene and evacuated to remove free gas. Several hundred pore volumes of kerosene were flooded through the core to reduce the interstitial water saturation to its terminal value. The core was then placed in an apparatus which permitted sealing off of the peripheral surface of the core and of one end. Water was then circulated past the exposed end. Water was imbibed by the core, and oil was produced. The amount of oil produced by this spontaneous water imbibition was measured and recorded as a function of time. After no more oil was produced, the sample was extracted with benzene and methanol, dried, resaturated with brine, and reduced, by flowing kerosene through the core, to the same water saturation it had at the start of the first imbibition test, 43.2 per cent. The imbibition experiment was then repeated on the extracted core.

The results of the two imbibition tests are illustrated in Fig. 4. As shown in this figure, the rate of imbibition was much greater for the extracted core than it was for the fresh sample.

RECAPITULATION

In recapitulation, the behavior of East Texas core samples at low water saturations revealed that:

1. The irreducible minimum water saturation was higher for fresh cores than it was for the same cores after extraction with organic solvents.

2. The irreducible minimum water saturation decreased with repeated determinations on fresh core samples.

TABLE 1 — COMPUTED RESISTIVITIES AT 40 PER CENT WATER SATURATION AS A FRESH CORE IS REPEATEDLY FLOODED

Waterflood Number	Resistivity ohm-meters
1	5.8
2	4.7
3	4.1
4	3.8
Sample extracted with Benzene	
5	3.2

Note: Resistivity of rock saturated with brine = 0.389 ohm-m
Resistivity of solution = 0.045 ohm-m

3. The electrical resistivity of a fresh core sample was higher at low water saturation than that of the same core at like saturation after extraction with organic solvents.

4. A fresh core sample readily imbibed water with expulsion of oil, but not as readily as did the same sample after extraction.

BEHAVIOR AT LOW OIL SATURATION

Of even more importance than the region of low water saturation is that of low oil saturation, since it is the behavior in the latter region that determines the residual oil saturation after displacement by water. The region of low oil saturation was explored by waterflooding tests conducted on fresh and aged core samples.

RESIDUAL OIL SATURATION AFTER WATER FLOODING

The experiments described previously, which furnished data on water saturation after flooding by oil, were also utilized to yield information on residual oil saturation after water flooding. From weights determined at each stage of the flooding experiments, the dry weights of the core samples, and the weights of the brine-saturated samples, it was possible to compute the residual oil saturation after each water flood.

After repeated water floods, some of the cores were extracted with different organic solvents to determine whether the nature of the solvent affected the behavior at low oil saturation. Extractions were made using hexane, methanol, benzene, toluene, and combinations of these on the different cores used in these tests.

As the fresh core samples underwent successive floods, their characteristics changed in such a manner that usually more residual oil was left after each repeated water flood than was left on the previous one.

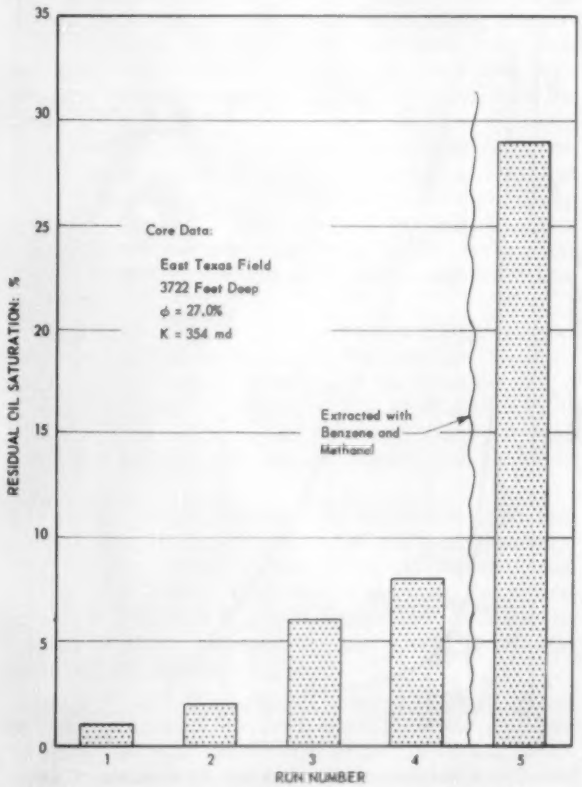

FIG. 5 — RESIDUAL OIL SATURATION AS CORE WAS REPEATEDLY FLOODED.

The average residual oil saturation for the nine core samples examined was about 12 per cent for the fresh samples, and increased on successive floods until it reached a value of about 30 per cent after extraction.

Of the nine core samples, three exhibited large changes as the cores aged. The average residual oil saturation of these three was 2 per cent after the first water flood and increased to an average of 33 per cent after extraction. Typical of these cores were the results shown in Fig. 5.

Additional information on the residual oil saturation was obtained from tests made on another group of core samples from the East Texas field. Core samples from this well were divided into four groups at the wellsite. One group was preserved by wrapping in metal foil and sealing in paraffin; another was put into containers under evacuated formation water; a third was placed in containers under aerated formation water; and the fourth group, entirely unprotected, was placed in cloth core bags. Samples from all groups were, in the laboratory, placed in 3 per cent salt water, evacuated, flooded to low water-saturation with kerosene, and then were waterflooded to residual oil. The results, subject to some question since the samples were not necessarily replicates, showed that the average residual oil saturation for the samples sealed in paraffin was about 13 per cent, for the samples kept under evacuated water was virtually the same, for the samples submerged in aerated water was 24 per cent, and for samples exposed to the air was 25 per cent.

Relative Permeability-Saturation Relations

Relative permeability-saturation relations calculated from data obtained in the foregoing repeated waterflooding tests served to give additional information on differences in behavior of fresh and aged cores in the region of low oil saturation.

Shown in Fig. 6 are data on water-oil relative permeabilities for a core sample subjected to repeated floods while fresh and to one flood after extraction. As illustrated in this figure, when compared at constant water saturation, the ratio of the relative permeabilities to water and to oil, respectively, increased as the floods were repeated. Extraction resulted in a further large change.

Recapitulation

In recapitulation, laboratory tests on the behavior of fresh and aged cores in the region of low oil saturation showed that:

1. Residual oil saturations on flooding fresh East Texas cores were unusually low, of the order of 15 per cent or less.
2. Residual oil saturations of aged cores were considerably higher, averaging possibly 30 per cent.
3. Residual oil saturations of fresh cores increased on repeated flooding.
4. Residual oil saturations of cores exposed to the air appeared to be higher than those of cores from which air was excluded.

CONCLUSIONS

It may be concluded as a result of this work that:

1. East Texas field cores must be preserved at the wellsite to prevent alteration of their behavior.
2. Cores from the East Texas field should not be extracted if they are to be used in laboratory tests to predict reservoir waterflooding behavior.

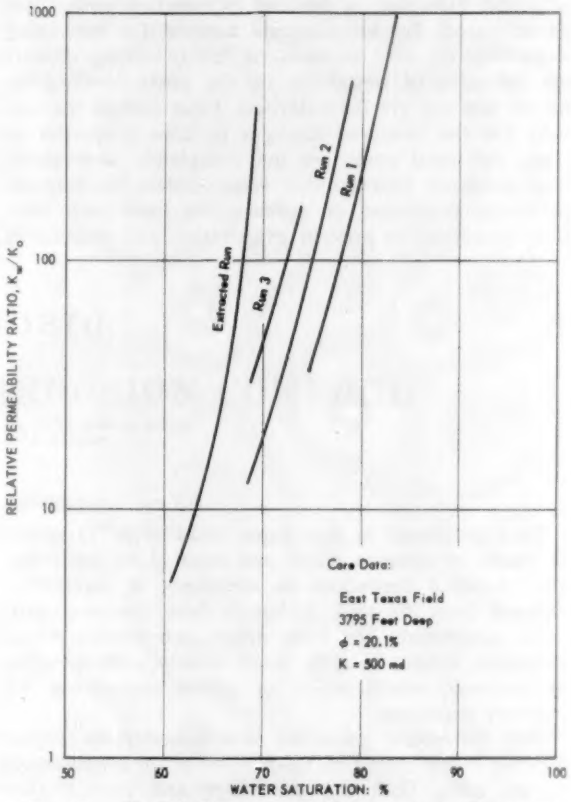

Fig. 6 — K_w/K_o-Saturation Relation as Sample Was Repeatedly Flooded.

3. Fresh East Texas field core samples imbibe water spontaneously. After extraction with organic solvents, they still imbibe water spontaneously, but their behavior differs substantially from that of the fresh cores.
4. There is a lack of knowledge as to whether the irreducible minimum water saturation given by capillary pressure measurement on fresh or on aged cores is more nearly representative of the connate water saturation in the reservoir at a distance above the water table. Consequently, the question of which should be used cannot be answered at this time except by comparison with directly determined connate water saturations made on cores cut with nonaqueous fluid.
5. It is recommended that fresh cores from other fields be examined to see if they exhibit this behavior. It would be most desirable wherever possible to obtain cores as little disturbed from their reservoir conditions as possible.

Perhaps the most important aspect of this research is the finding that the residual oil remaining in waterflooded reservoirs may be much lower than would be expected from the results of core tests on extracted or weathered cores. The importance of this possibility cannot be overlooked in the estimation of reserves and in the selection of the recovery method to be employed in the production of a particular reservoir. Conclusions regarding the feasibility of secondary recovery operations and the influence of such factors as a free gas saturation during a water flood must be based on experiments using cores whose behavior adequately represents that of the in-place reservoir rock.

At the present time it seems most likely that alterations in the nature of the solid surfaces of the rock are responsible for the observed changes in gross flooding

behavior. However, a detailed explanation cannot yet be advanced, for an adequate method for measuring wettability of core surfaces or for observing directly the influence of wettability on the gross flooding behavior has not yet been devised. Even though the reasons for the observed changes in core properties of fresh and aged cores are not completely understood, it is presently believed that restored-state flooding experiments conducted on cores which have been carefully preserved to prevent evaporation and weathering of the fluids will provide more representative values of residual oil than will similar experiments on cores which have been extracted with organic solvents, dried, and resaturated.

ACKNOWLEDGMENT

The authors are indebted to R. V. Randall who did much of the initial experimental work and to K. H. Ribe who also performed several original experiments.

DISCUSSION

UZZELL S. BRANSON, JR.
MEMBER AIME

CONSULTING ENGINEER
DALLAS, TEX.

Data presented in this paper show wide variations in values of connate water and residual oil saturation after flooding dependent on treatment of cores after removal from the well. Although these deviations partially compensate for each other, determining which technique results in data more closely corresponding to reservoir conditions is of prime importance for recovery estimates.

One difference presented was considerably higher residual water found in fresh cores after displacement by oil using both the centrifuge and porous plate techniques. The authors suggest that coring with non-aqueous fluids would determine which set of values more nearly corresponds to reservoir conditions. Data published earlier* indicate that restored state measurements on "aged" cores usually give slightly higher connate water saturations than are obtained by coring in oil base fluids. These data, including as the nearest available comparison samples from the Woodbine sand in the Hawkins pool, suggest that data from thoroughly cleaned cores is the more accurate with regard to connate water content.

Flood test measurements showed higher residual oil saturations on "aged" samples than on "fresh" samples. Here again, direct core analysis measurements of residual oil content, particularly that of samples cut in the watered out producing zone, would be helpful in deciding which set of data is correct. Residual oil measured in cores cut in aqueous drilling fluids has been found in reasonable agreement with that measured in flood tests in many cases. Data presented in this paper may explain some cases that have not corresponded to this rule.

Another item of interest would have been a more complete explanation of the methods of determining saturations and assuring their reliability, particularly oil saturations on repeated flooding.

*W. A. Bruce and H. J. Welge: "The Restored State Method for Determination of Oil in Place and Connate Water." *API Drilling and Production Practice* (1947) 166.

AUTHORS' REPLY to UZZELL S. BRANSON, JR.

We agree with Mr. Branson on the importance of laboratory experiments yielding results which accurately portray reservoir behavior. Unfortunately, as was mentioned in the paper, data are not available at this time on comparisons of water content of cores from oil zones cut with non-aqueous fluids and laboratory measurements. Until such time as a number of comparisons of this nature are available, it behooves us to keep an open mind in the matter.

Referring to the methods used to measure saturations, gravimetric measurements were used as the primary standard. Large samples were used where repeated floods were made to allow volumetric checks and to minimize the importance of loss of sand grains. Careful handling of the samples along with the use of dense salt water improved the accuracy of weight determinations. Evacuated fluids were used to prevent the possibility of a free gas saturation introducing errors. ★★★

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T. P. 4055

INTRODUCTION

The external corrosion of casing is one of the most important problems facing the present day production man. A 1953 NACE report[1] estimated the annual cost of casing corrosion at $2,200,000 in 22 fields studied. The fields represented only 10 per cent of the wells in the United States. It was significant that 77 per cent of the failures reported were due to external corrosion.

A variety of means for combatting the casing corrosion problem have been discussed in papers such as the NACE survey[1] mentioned previously. No attempt to review these will be made in this paper. The scope of this paper has been limited to a discussion of the following major items: (1) an instrument for studying external electrolytic corrosion; (2) use of this instrument to determine the quantity of protective current required to prevent corrosion of casing; and (3) problem of accelerated external corrosion of the oil string at the base of the surface string.

ELECTROCHEMICAL MECHANISM OF CORROSION

It is generally believed that one major cause of external corrosion is the existence of electrolytic cells operating between various formation waters. A theoretical discussion of the role of earth potentials in casing corrosion has been presented by L. de Witte and F. J. Radd.[2]

A brief picture of the electrolytic corrosion action between two different formations (A and B) is presented in Fig. 1. This picture is a review to many but is given to insure clarity. In the anode area, oxidation takes place as iron ions go into solution in formation A as a product of corrosion. In the cathode area, reduction takes place and hydrogen atoms are formed at the boundary between the pipe and formation B. The flow of electrons, as indicated, is into the pipe at the anode or corroding area and out of the pipe into the formation at the cathode. In order to conform with regulations of this journal, the flow of a conventional current (*I*) is also indicated in this sketch. All subsequent references will be to this so-called conventional current flow and will be indicated by the symbol (*I*). As this action takes place the layer of hydrogen developed on the cathode offers a resistance to the flow of current in the cell. It is said that the cathode has been *polarized*.

This polarizing film can be removed by addition of a so-called depolarizing agent which reacts with and removes this hydrogen film. Such an agent must be present in order for this corrosion reaction to go at a rate sufficient to cause a severe corrosion problem. The two common depolarizing agents are: (1) oxygen, which readily reacts with hydrogen to form water, and (2) certain bacteria which use atomic hydrogen as part of their life process. It is not difficult to explain the presence of these agents. Oxygen may be present in some very shallow formations. Sulfate reducing bacteria are found to exist in nearly any ground where mud pits might be dug.

THE CASING POTENTIAL PROFILE

INSTRUMENTATION

A sketch of the equipment* used in determining casing potential profiles is shown in Fig. 2. The tool is run in the hole using a hoist truck with a three-conductor cable. This tool must be run with tubing and rods out of the hole and should be run with the flow line disconnected. By proper choice of electrode size it can be run in any size casing. The electrodes must be run in an open hole or a hole filled with oil. Measurements cannot be made while immersed in water.

The tungsten carbide-tipped knives serve as the electrical probes and are spaced 25 ft apart. The potential difference along a 25-ft section of casing is measured with a potentiometer to an accuracy of about 5 mv. Current flowing in the pipe can then

[1]References given at end of paper.

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*Acknowledgment: The equipment used in this work was developed and built by Stanolind Oil and Gas Co. We wish to thank them for the use of this equipment.

be calculated, provided the resistance of the casing is known.

Interpretation of Results

A plot of these potential differences vs depth of the well has been designated as a casing potential profile. Since the pipe is of essentially constant resistance, the potential profile is the same shape as a plot of current vs depth. A sketch of a typical casing potential profile is shown in Fig. 3.

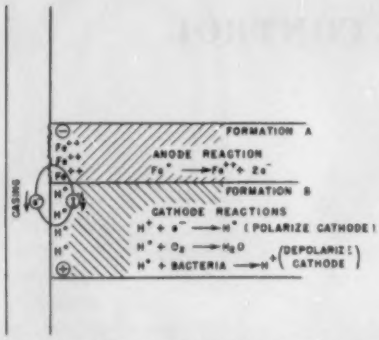

Fig. 1 — Electrochemical Corrosion of Casing.

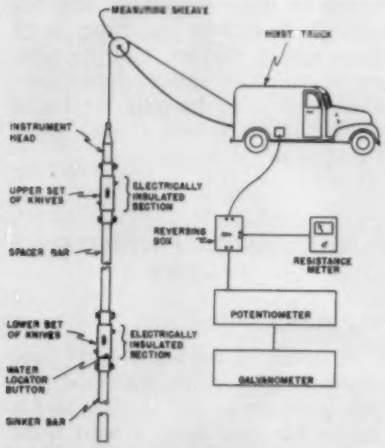

Fig. 2 — Casing Potential Profile Instrument.

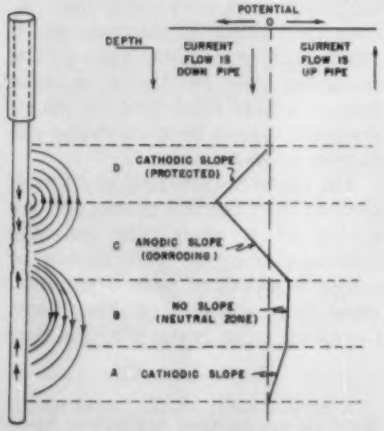

Fig. 3—Casing Potential Profile.

Analysis of this curve shows the curve sloping upward to the right in area A where current enters the pipe. According to Fig. 1, this is a cathode area. In area B, no current is entering or leaving the pipe. Thus the curve has no slope. In area C, current leaves the pipe to form an anodic or corrosive area. This is noted by a slope upward to the left. Area D is another cathode area. It is important to note that the direction of current flow in the pipe is not important. The important fact is the rate at which current enters or leaves the pipe. This is shown by the *slope* of the potential profile.

FIELD STUDIES USING POTENTIAL PROFILES

Corrosion Defined by Profiles In Four Fields

The casing corrosion problem in four fields was studied during 1954. Several wells were selected from each field in order to get a good picture. A series of profiles for one well in each field have been selected for this paper. These can be briefly presented:

NORTHWEST BURNETT FIELD, ELLIS COUNTY, KAN.

Fig. 4 shows the profiles for a well in Western Kansas. The profile taken with no current applied shows an anode slope in the region 900 ft to 1,400 ft. This is approximately the depth of the Dakota Sand in this area. It is noted that two previous failures in this well at 900 ft and 1,010 ft are within this zone defined as corrosive by the profiles. All the casing corrosion failures in this area have been within this Dakota zone and occur some 10-15 years after completion of the wells.

DRISCOLL FIELD, DUVAL COUNTY, TEX.

In Fig. 5 an anode area is noted from 500 ft to 900 ft. This corresponds to the hydrogen sulfide-containing Oakville Sand in this area. All failures in this field have been in this range of depths. These failures have started occurring about 12 years after completion of the wells.

RINCON FIELD, STARR COUNTY, TEX.

In Fig. 6 an anode area is noted from 1,000 ft to 2,400 ft. According to available electric logs, there are a number of water zones in this area. Casing from two wells has been examined and a severe casing corrosion problem noted in both wells. Several casing failures have recently been experienced in this range of depths in Rincon wells.

SAN MIGUELITO FIELD, VENTURA COUNTY, CALIF.

In Fig. 7, a very long anode slope is noted from 2,500-4,600 ft. From electric log data, it appears that a large number of water zones have contributed to this long smooth anode area.

The casing from this well was recovered to a depth of 5,200 ft. It was found that there were 17 holes in the depth interval 3,200-3,700 ft and one hole at 4,400 ft. Severe pit type corrosion was found in the interval 2,200-4,600 ft. This is approximately that interval defined as corrosive by the profile. There was also a much less severe smooth corrosion in the area 1,000-2,200 ft and 4,600-5,200 ft which were not shown to be anodic by the profile. The one disappointing thing was that the profile did not predict the extremely severe corrosion occurring in the interval 3,200-3,700 ft where 16 of 17 holes were observed. However, it was felt that the qualitative correlation was not bad.

From the above tests described in four widely varying fields, the casing profile has shown electrolytic corrosion to be a major factor in all four fields.

Cathodic Current for Protection of Casing

The amount of current required to completely remove all the anode areas was determined by running a series of profiles with varying amounts of protective (or cathodic) current applied to the casing. Fig. 8 is used to describe the system used. Current from an external power source is put into the pipe at point A by flowing through the ground

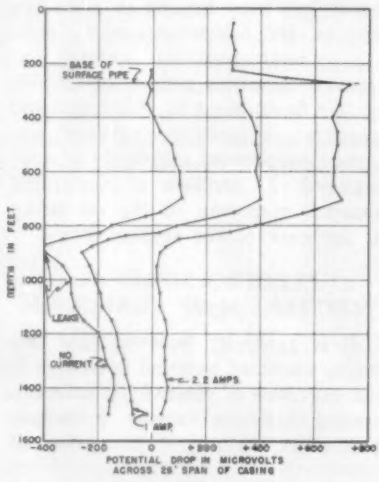

Fig. 4 — Casing Potential Profile, Northwest Burnett Field, Kan.

from two carbon anodes (4 in by 5 ft) buried about 100 ft from the wellhead. Thus the entire pipe has been made the cathode and is not subject to corrosion. The potential profile of a well fully protected would be, as pictured in Fig. 8, a gradual slope upwards to the right.

CURRENT REQUIRED

Looking again at Figs. 4, 5, 6, and 7, the amounts of current required can be easily seen. Actually, profiles were determined at several currents for each well. Only the profiles using the current required to barely remove all anode areas are shown in these figures. It is seen that a current input of 3 amps was sufficient to remove all the anode areas to depths up to 4,400 ft in each well being discussed. No anode areas were found deeper than this in wells tested. However, in one California well it was shown that current actually went to depths of 8,700 ft when a current of 7.5 amps was applied. It is believed that it would have been possible to remove anode areas to this depth if they had been present.

DISTRIBUTION OF CURRENT ON CASING

It is believed that current applied to the casing enters the pipe at various intervals to considerable depths. As mentioned above protective current flow was measured to depths of up to 8,700 ft. Calculations based on the profiles can be used to show the approximate distribution of current for wells where profiles have been run. These calculations have been made in Fig. 9 for one Kansas well. Currents were calculated over each 25-ft interval of casing. An ohmic resistance of 500 micro-ohms was assumed for each 25-ft section of casing using this value and potential drop as measured. A total of 2.2 amps were introduced to the well. It entered the casing at various intervals to the depth to which measurements were made.

A total of 1.5 amps entered the system as protective current for the casing below the surface pipe. The remaining 0.7 amp entered the surface pipe itself. It is further seen that only 0.6 amp traveled back to the rectifier by way of the casing. This means that 0.9 amp of current transferred to the surface pipe from the casing. This plus the 0.7 amp entering the surface pipe from the soil means that 1.6 amps are delivered back to the rectifier system through the surface pipe. In summary it is seen that 1.5 amps are giving cathodic protection to the casing and 0.7 amp giving protection to the surface pipe with 0.9 amp transferring at the base of the surface pipe.

EFFECT OF TIME ON CURRENT REQUIREMENTS

The potential profiles are almost certain to shift after long periods of current applications. This shift was shown to be small in Kansas wells where depths of less than 1,500 ft were involved. In deeper California wells this shift was appreciable after several days. In all cases, the shift was such that there was a decrease in the current required for removal of all the anodic areas. This is due in part to a slow build-up of the polarizing film of hydrogen discussed earlier. In addition, there is an appreciable pH increase in the immediate vicinity of the cathodic pipe. This results in precipitation of protective films of salts such as $CaCO_3$. This film effectively reduces the total area of pipe to be protected.

In the casing recovered from the California well an incomplete, thin film of calcium carbonate was found to depths of 5,200 ft. This was thought to be a result of cathodic protection applied for six months.

ACCELERATED CORROSION AT THE BASE OF THE SURFACE PIPE

EVIDENCE OF ACCELERATED CORROSION

Examination of all the profiles of wells with current applied showed a very sharp break in the curve at the depth of the base of the surface pipe. If our original analysis of the curve is correct, the curve indicates a very

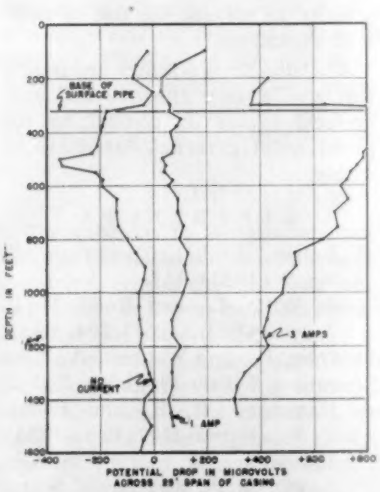

FIG. 5 — CASING POTENTIAL PROFILE, DRISCOLL FIELD, TEX.

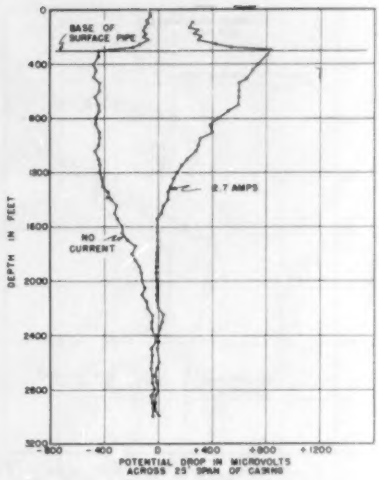

FIG. 6 — CASING POTENTIAL PROFILE, RINCON FIELD, TEX.

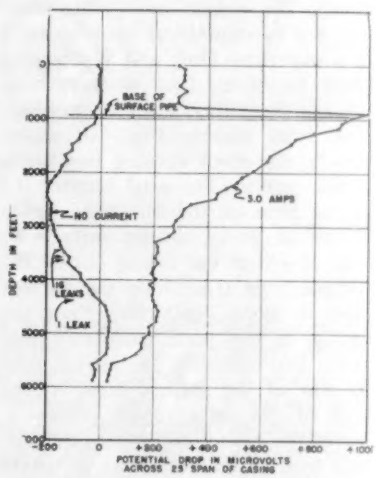

FIG. 7 — CASING POTENTIAL PROFILE, SAN MIGUELITO FIELD, CALIF.

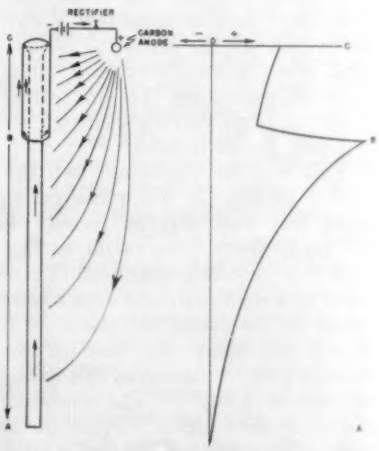

FIG. 8 — CATHODIC PROTECTION OF WELL CASING.

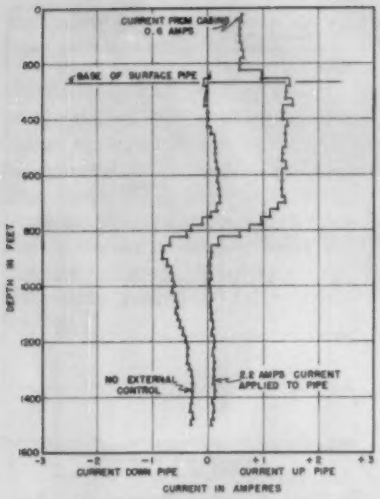

FIG. 9 — CASING CURRENT PROFILE, NORTHWEST BURNETT FIELD, KAN.

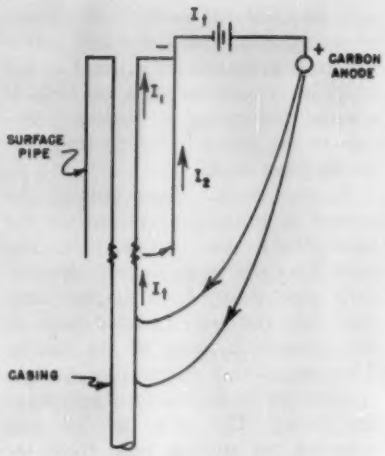

FIG. 10 — CORROSION AT BASE OF SURFACE PIPE.

FIG. 11 — MILD CORROSION AT BASE OF SURFACE PIPE.

severe anodic or corrosive area at this depth. The possibility of this problem was recognized as early as 1951 in a paper[3] by Doig and Wachter of Shell. However, later workers have not felt that this is a severe problem.

A brief sketch (Fig. 10) shows clearly the effect causing this break in the profile. The total current (I_t) at the base of the oil string has a choice of going to the surface by way of either the casing (I_1) or the surface pipe (I_2). Since the surface pipe is more conductive than the casing, it has been calculated that about two-thirds of the current goes by way of the surface pipe. At the base of the surface pipe current I_2 leaves the casing and enters the surface with a resultant severe corrosion on the casing.

A laboratory model of this system was set up. A severe etching of the inner pipe at the base of the outer pipe was noted after only 24 hours.

It is believed that the profile and laboratory data indicate that a serious attack on the oil string is initiated when a well is placed under cathodic protection. To get further proof, 5 amps current were left on one well for six months.

This was the California well discussed in Fig. 7. When the casing from this well was recovered the section in the vicinity of the surface pipe was carefully examined. Large areas of a mild corrosion attack were noted on the casing for about 20 ft above and below the base of the surface pipe. A section of this casing is pictured in Fig. 11. The maximum depth of penetration was about 20 mils. The corrosion product was identified as $Fe_2O_3 \cdot H_2O$. This type corrosion was not found at any other location on the 5,200 ft of pipe recovered. It seems very likely that the effect noted in this well is due to current transfer at this point. However it is not of sufficient severity to give failures in less than five to 10 years. The severity is, of course, a function of the current transfer at the base of the surface pipe. In this time the problem can be more clearly defined and adequate preventative measures can be taken before damage results. To further check this phenomenon it is hoped that other casing can be recovered after being cathodically protected.

POSSIBLE MEANS OF PREVENTING ACCELERATED CORROSION

Several possible means of preventing this corrosion have been suggested. Some of these are listed and briefly discussed below.

1. A metallic bond between the base of the surface pipe and the oil string should provide a metallic path for the current and thereby eliminate the new problem. A means of providing a connection on old wells is not visualized, but it is believed that placing a centralizer at this point on new wells should provide this bond. This has been done in several wells.

2. The placing of an insulator between the oil string and surface pipe should prevent the current transfer to the surface pipe from the oil string. This non-electrolyte, perhaps some oil base material, would have to be maintained at least a few feet below the base of the surface pipe. This is probably not a practical thing to do.

3. If the current can be removed from the casing at the base of the surface pipe, all the pipe above this would effectively be bypassed. This could be done by means of an insulated wire run in with the tubing or by insulating the tubing and using it as a conductor.

The ideas listed are being tested in the laboratory and in the field. It is believed that the problem of the surface pipe can be resolved and should not rule out cathodic protection as a means of preventing external casing corrosion.

CONCLUSIONS

1. Casing potential profiles were effective in showing the extent and magnitude of external, electrolytic casing corrosion in four fields.

2. Casing potential profiles were used to show that 1 to 5 amps cathodic current were required to remove all gross anode areas to depths of 6,000 ft in the wells studied.

3. Application of cathodic protection was shown to cause an accelerated attack on the oil string opposite the base of the surface pipe. However, this problem is not of sufficient severity to prevent the use of cathodic protection.

4. Cathodic protection apparently will give a very effective and economical means of combatting the problem of external corrosion of casing.

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★★★

ANALYSIS of PRESSURE FALL-OFF CURVES OBTAINED in WATER INJECTION WELLS to DETERMINE INJECTIVE CAPACITY and FORMATION DAMAGE

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ABSTRACT

The paper presents a practical method of utilizing pressure fall-off data obtained when a water injection well is shut in for determination of: (1) the static reservoir pressure, (2) the potential water injective capacity (md-ft) of the formation, and (3) the formation damage (skin effect) surrounding the wellbore. In the development of the method, equations are presented which give the theoretical background for predicting the behavior of water injection wells. Certain physical factors which limit the application of the method are discussed. The procedure and the relevant precautions in obtaining the data are discussed. A sample analysis and computation from an actual pressure fall-off curve is illustrated. Finally, general characteristics of pressure fall-off curves obtained in several reservoirs are presented.

INTRODUCTION

Theoretically, in an injection well the flow of water into the formation will continue as long as the sand-face pressure is greater than the reservoir pressure. However, in practice, engineers have observed that upon stopping injection and opening the wellhead to atmospheric pressure, some wells backflow water for time intervals ranging from several seconds to several hours although the sand-face pressure, as calculated from the hydrostatic head, is considerably greater than the static reservoir pressure. Further, field observations indicated that upon shutting in a water input well, the wellhead pressure does not drop off immediately, but a pressure decline occurs lasting from several seconds to several days. These observations make it evident that when an input well is shut in, a residual pressure lingers in the vicinity of the wellbore which is greater than the average reservoir pressure. This residual pressure declines first rapidly, then more slowly, to the static reservoir pressure; therefore, it is called transient back-pressure or pressure fall-off.

The first step in investigating the mechanism of pressure fall-off is to establish what general conditions are necessary for its occurrence, and to this end, Dickey and Andresen[1] have presented a qualitative explanation describing the mechanism. They point out that the formation pressure gradient in the vicinity of the well does not disappear immediately when the input well is shut in, as if the system were filled with a totally incompressible fluid, but it is maintained by the expansion of the compressible fluids and by the elasticity of the formation. In such a compressible system the decrease in pressure is possible only to the extent that the water front continues to advance until the pressure is equalized.

The principal aim of this paper is three-fold; namely, (1) to present a theoretical quantitative analysis of pressure fall-off data, (2) to present an application of the developed theory to field data, and (3) to discuss the general characteristics of actual pressure fall-off curves. Under (1), theoretical equations dealing with such factors as compressibility of the fluid-reservoir system, mobility of the fluids and certain physical restrictions that

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[1]References given at end of paper.

tend to limit the applicability of the equations to field data will be discussed. Under (2), analysis of an actual pressure fall-off curve in terms of the static reservoir pressure, the injective capacity of the formation, and the formation damage or the skin effect will be presented. The injective capacity is defined as the product of the effective water permeability of the reservoir in millidarcys and the net sand thickness of the reservoir in feet. Formation damage, or as it is appropriately referred to by Van Everdingen[6] and by Hurst[8] as the skin effect, refers to that portion of the formation in the immediate vicinity of the wellbore, the permeability of which has been altered by the well completion procedure or subsequent events so that a substantial difference exists between its permeability and that of the formation as a whole. Finally, under (3), the general characteristics of actual fall-off curves will be illustrated.

THEORY

The mathematical analysis of pressure fall-off curves involves consideration of two distinct processes: (1) the pressure rise during water injection, and (2) the pressure decline during subsequent shut-in. In the first, the pressure will rise analogously to the lowering of pressure in oil producing wells. In the second, the pressure decline is analogous to pressure build-up in an oil producing well. Therefore, the fluid flow equations which have been developed for producing wells are also applicable to injection wells, providing suitable modifications are made for the differences in the direction of flow and in the physical properties of the fluids.

The mathematical presentation for the two processes occurring in an input well, which are studied separately below, are adaptations of the formulae developed by Theis[2] and by Horner[7] for producing wells. The formulae were derived on the concept of "point-source" solution. As will be evident later, they do not involve complicated integrals and Bessell functions which are frequently encountered in transient problems and which are difficult to use.

Pressure Rise During Injection

The theoretical rise in pressure P_r at radial distance r from an input well caused by injecting water at constant rate Q into an extensive reservoir of uniform thickness and permeability is given by Equation 1[2,3]:

$$P_r - P_s = \Delta P = \frac{70.6\, Q\, F\mu}{k\, h}\left[-Ei\left(-\frac{948.2\, r^2 f\mu c}{k\, t}\right)\right]$$

$$= \left(\frac{70.6\, Q\, F\mu}{k\, h}\right)\left(-0.5772 - \ln U + \frac{U}{1\cdot 1!} - \frac{U^2}{2\cdot 2!} + \cdots\right) \qquad (1)$$

where: $U = \dfrac{948.2\, r^2 f\mu c}{k\, t}$

$[-Ei(-U)]$ = Symbol for an exponential integral whose values are positive in sign and are tabulated in the literature[4], or whose values can be calculated by the above converging series.*

The apparent value of Equation 1 is that it gives part of the theoretical background for predicting the behavior of water input wells. Perhaps the paramount value of Equation 1 is that the Ei function possesses, as will be discussed, a unique behavior which leads to the derivation of greatly simplified formulae for calculating kh, P_s, injection pressure $P_{r_{wi}}$, and skin effect.

For small values of $\frac{r^2}{t}$ compared to the value of $\frac{k}{948.2\, f\mu c}$, U will be so small that the series following the first two terms in the series in Equation 1 may be neglected. Thus, where values of $\frac{r^2}{t}$ are relatively small, e.g., when r is equal to the wellbore radius r_w, Equation 1 may be approximated as shown in Equation 2[5]:

$$P_r - P_s = \left(\frac{70.6\, Q\, F\mu}{k\, h}\right)\left[\ln\left(\frac{1}{U}\right) - 0.5772\right]$$

$$= \left(\frac{70.6\, Q\, F\mu}{k\, h}\right)\left[\ln\left(\frac{k\, t}{948.2\, r^2 f\mu c}\right) - 0.5772\right]$$

$$= \left(\frac{70.6\, Q\, F\mu}{k\, h}\right)\left[\ln\left(\frac{e^{-0.5772}\, k\, t}{948.2\, r^2 f\mu c}\right)\right]$$

$$= \left(\frac{70.6\, Q\, F\mu}{k\, h}\right)\left[\ln\left(5.93 \times 10^{-4}\, \frac{k\, t}{r^2 f\mu c}\right)\right] \qquad (2)$$

The approximation is acceptable when U is less than 0.02. Converting to the logarithm to the base 10 (designated as log), Equation 2 can be rewritten in either of two useful forms, Equation 3 or 4:

$$P_r - P_s = \left(-325\, \frac{Q\, F\mu}{k\, h}\right)\left[\log r - \tfrac{1}{2}\log\left(5.93 \times 10^{-4}\, \frac{k\, t}{f\mu c}\right)\right] \qquad (3)$$

$$P_r - P_s = \left(162.5\, \frac{Q\, F\mu}{k\, h}\right)\left[\log t - \log\left(1.68 \times 10^{3}\, \frac{r^2 f\mu c}{k}\right)\right] \qquad (4)$$

The only variables in these equations are the pressure P_r, the distance r, and the time t.

When t is constant, Equation 3 will be the equation of a straight-line plot of P_r against log r. In this form, Equation 3 can be used to calculate the variation of pressure with distance from the wellbore for a given injection time and constant injection rate. However, for very large values of r, or if it is desired to calculate the effective pressured radius, the more precise method, Equation 1, should be used. For example, plot of P_r vs log r using Equation 1 will give a straight-line curve that coincides with the straight-line curve as calculated by Equation 3 for a limited range away from the wellbore. Then a point of deflection will occur and the curve from Equation 1 will approach asymptotically the static reservoir pressure. The point of deflection can be used to calculate, for all practical purposes, the effective pressured radius.

Equation 4 can be used to predict the variation in the theoretical injection pressure in the wellbore as a function of the injection time for a given constant injection rate. For example, when $r = r_w$ and $P_r = P_{r_{wi}}$ straight-line plots of $P_{r_{wi}}$ (the injection pressure) vs log t can be obtained for each chosen constant injection rate.

In both Equations 3 and 4, the slope of the straight-line plot is represented by the quantity on the outside of the brackets. Usually the unknown factors occurring in the slope of the line are k and h. Theoretically, it is possible to estimate the product kh, the injective capacity

*See Nomenclature for explanation of other terms.

of the reservoir, by plotting the observed injection pressure P_i against log t and evaluating the slope of the resulting straight line (Equation 4) to calculate kh.

In the subsequent section it will be evident that the values of kh and static reservoir pressure P_s can be more readily derived from pressure fall-off data. Then the derived values can be inserted into Equation 4 to calculate the theoretical injection pressure. Comparison of the theoretical injection pressure with the observed injection pressure provides a measure of the skin effect. This approach is similar to those of Van Everdingen[6], of Thomas[7], and of Hurst[8].

Pressure Fall-Off During Shut In

A mathematical approach similar to the one above will be applied to the analysis of pressure fall-off curves. When an input well is shut in (after being on injection at a constant rate Q for time t), the pressure P_r at radial distance r from the well will decline with shut-in time according to Equation 5[2,3]:

$$P_r - P_s = \left(\frac{70.6\, Q\, F\mu}{k\, h}\right)\left\{\left[-Ei\left(-\frac{948.2\, r^2 f\mu c}{k(t+\delta)}\right)\right] - \left[-Ei\left(-\frac{948.2\, r^2 f\mu c}{k\,\delta}\right)\right]\right\} \quad . \quad . \quad . \quad . \quad (5)$$

where: δ = time elapsed since closing the well, hour.

As in the preceding section, for small values of its argument the Ei function may be closely approximated by a logarithmic function. In most cases where $r = r_w$, after the first few seconds of shut-in time, the argument is sufficiently small to validate the approximation. This procedure gives the simplified Equation 6:

$$P_{r_w} - P_s = \left(\frac{162.5\, Q\, F\mu}{k\, h}\right) \log\left(\frac{t+\delta}{\delta}\right) \quad . \quad . \quad (6)$$

where: log = logarithm to the base 10.

In actual practice, normally the injection rate is not held constant over the injection history up to the time t of shut in. However, sufficient precision is obtained by substituting in Equation 6 the stabilized injection rate Q_s for Q prior to shut in and the psuedo-injection time t_e for t, where t_e is equal to cumulative volume of water injected divided by the stabilized rate Q_s and then converted to the same time unit as is used for δ. Applying the substitution, Equation 6 is rewritten as Equation 7:

$$P_{r_w} - P_s = \left(\frac{162.5\, Q_s\, F\mu}{k\, h}\right) \log\left(\frac{t_e+\delta}{\delta}\right). \quad . \quad (7)$$

Theoretically, when $\frac{t_e+\delta}{\delta}$ is plotted on a logarithmic scale against P_{r_w} on a linear scale, a straight line is obtained, the slope of which is equal to $\frac{162.5\, Q_s\, F\mu}{k\, h}$, from which the effective injection capacity kh can be calculated. Extension of the straight line to infinite shut-in time, $\frac{t_e+\delta}{\delta} = 10^0 = 1$, gives the value of the average static reservoir pressure P_s for a reservoir that behaves as if it were infinite in size.

In making the above plot, it is easier to visualize the pressure fall-off process by plotting the reciprocal of the time ratio or $\frac{\delta}{t_e+\delta}$ against P_{r_w} so that the pressure is shown decreasing with increase in shut-in time.

Physical Limitations

Theoretically, the foregoing equations apply to the following imposed well-fluid-reservoir assumptions: that a single well of infinitesimal diameter penetrates the entire thickness of the reservoir and, during injection, is charging the reservoir continuously at a constant rate; that only a single fluid is flowing; that the reservoir is homogeneous, of infinite areal extent, wherein the permeability is constant at all times and places.

These theoretical restrictions have varying degrees of importance in practice. Generally it is evident from the literature that many of the major performance characteristics of oil reservoirs can be described in at least semi-quantitative fashion by assumptions of substantial uniformity. Specifically, most of the physical limitations can be handled by incorporating suitable additions and modifications in the equations; or by choosing suitable portions of data which predominantly reflect the behavior in the region of the reservoir under investigation; or by procuring data in the early part of the injection history.

The restrictions imposed by the assumptions with respect to the well are not usually serious in practice. For example, the variation in the injection rate can be corrected for by breaking up the injection history into intervals for which the respective rates are constant[2]; however, in most cases, such precision is unwarranted. The effect of a well failing to penetrate the entire reservoir thickness is apparently negligible in most cases. The size of the wellbore diameter is also negligible[9].

The restriction that single phase fluid is flowing offers fewer uncertainties with respect to input well, as compared with its application to oil producing wells. If the fluid mobility and compressibility are considerably different ahead of the flood front, then those in the watered-out region, a change in the shape of the pressure fall-off curve should be observed in the latter stages of the shut-in time.

The restrictions on the application to the reservoir brought about by the assumptions are of more serious nature than those imposed on the well-fluid system; however, if adequate precautions are observed the computations will not be vitiated by the heterogeneity or size of the reservoir. For example, the effect of boundaries can be considered by more elaborate analyses[2,10,11], once they are located. Usually if the data are obtained during early injection history, the reservoir will behave as if it were infinite in size. The effect of other wells in the reservoir on the input well can be considered by a technique developed for producing wells, using the concept of superposition[5]. The effect of heterogeneity in permeability (lateral and vertical) can hardly be foretold, but in many cases apparently a dynamic averaging process occurs that makes the reservoir behave as if it possessed a high degree of homogeneity. It is believed that the most serious difficulty in analyzing pressure fall-off data occurs in reservoirs composed of several strata of widely different permeabilities, wherein the strata are separated by impermeable laminae. This problem is not treated analytically in this paper.

In addition to the above factors which tend to limit the application of the equations, two other factors which are inherently operational will be mentioned: (1) the after-injection effect, and (2) the skin effect. Both factors have been discussed by other writers for the analogous conditions existing in oil producing wells[6,8]. Because the conditions giving rise to the factors occur in the wellbore region, they affect the shape of the pressure

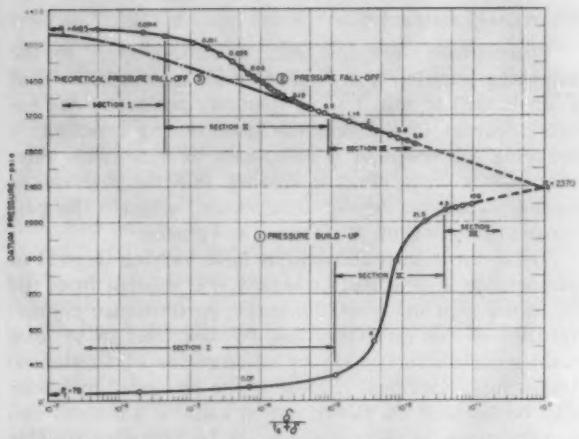

FIG. 1 — PRESSURE BUILD-UP AND PRESSURE FALL-OFF PERFORMANCES OF WELL A-1, FIELD A. NUMBERS BESIDE PLOTTED POINTS INDICATE SHUT-IN TIME IN HOURS.

fall-off curve in the early portion of the shut-in time. These effects cause deviations from linearity of the curve plotted according to Equation 7 and, as will be shown in the subsequent section, must be taken into consideration in order that the correct sections of the pressure fall-off curve may be used in making the analysis. The duration of both effects can be estimated by the method of Miller, Dyes, and Hutchinson[12].

APPLICATIONS

As part of research to study the behavior of water injection wells, pressure fall-off data were obtained on a number of wells. This section records the preliminary findings of the study.

MEASUREMENT OF PRESSURE FALL-OFF

For wells which when shut in display at the wellhead positive pressure over sufficient periods of time to reflect the effects of the reservoir in the majority of the pressured area away from the well, the pressure fall-off may be measured by a calibrated Bourdon gage.

When the rate of decline of wellhead pressure is too rapid, it is necessary to record the data with a bottom-hole pressure gage. In this case, the pressure gage is lowered through a lubricator to datum depth while injecting in order not to disturb the stabilization period, and then the well is shut in. Before shutting-in, it is recommended that the stabilization, consisting of continuous injection at constant rate, should be a minimum of one week.

ANALYSIS AND COMPUTATIONS OF PRESSURE FALL-OFF CURVES

It will be recalled that a number of reasons were pointed out in the theoretical section why the observed pressure fall-off data does not plot as a straight line on semi-log paper as is mathematically stipulated in Equation 7. It was also pointed out that presumably the influence of most factors which cause departure from linearity varies from well to well and occurs over different and over limited ranges of the shut-in period. Hence, the observed pressure fall-off curve selected to illustrate the analysis and computations below is not to be considered typical of the curves usually obtained in practice. It is, as will be evident later, a sort of idealized curve, but its shape will facilitate an appreciation of the salient features of the behavior observed in all cases.

In Fig. 1, data are shown in the form of three curves for a California well A-1, field A. Curve 1 is the observed pressure build-up; curve 2 is the observed pressure fall-off; and curve 3 is the calculated theoretical pressure fall-off. This well had a unique operational history, in that originally it was a producer at which time curve 1 was obtained, and later it was an injector at which time curve 2 was obtained. The well was completed 400 ft from the nearest well in a watered-out area of an oil reservoir and came in and remained a water producer (100 per cent cut) for a period of two months. Then it was reconditioned and converted to an injector.

Because curves 1 and 2 represent analogous processes, the analysis and computations will be applied to each. For the purpose of analysis, each curve is split into sections I, II and III, as designated in Fig. 1. The first few seconds of shut-in occur in section I. For this section, Equation 5 is more applicable than Equation 7; however, neither equation rigorously holds in section I because each is based on the concept of a point sink. Usually this section is not recorded in most pressure surveys, but if recorded it can be used to estimate the producing or the injection pressure prior to shut-in. Section II may extend from several seconds to several hours in length and reflects predominantly for curve 1 the effects of skin and after-production, and for curve 2 it reflects the effect of skin (the effect of "after-injection" is negligible because the data were obtained at the wellhead while the wellbore was completely filled with water). Section III extends over the latter period of shut-in and reflects for curves 1 and 2 the behavior of the reservoir. Section III, therefore, is used for the computation of static reservoir pressure, and injective capacity.

The average static reservoir pressure P_s for a reservoir behaving as if it were of infinite extent is obtained by extending section III of either curve to infinite shut-in time (value of 10° on the abscissa scale). In this way, for each curve the static reservoir pressure, as shown in Fig. 1, is estimated as 2,370 psia.

The productive or the injective capacity kh of the reservoir is computed from the slope of section III. The numerical value for the slope can readily be obtained by taking the difference in the pressure values over one logarithmic cycle. In this manner, the slopes were read for curve 1 as 175 and for curve 2 as 275. From Equation 7 the slope is equal to $\frac{162.5\, Q\, F\mu}{kh}$. The calculation of values of kh obtained from the slopes are shown below.

$$kh = \frac{162.5\, Q\, F\mu}{(\text{slope})}$$

For curve 1

$$kh = \frac{(162.5)(263\ \text{B/D})(1.02)(0.35\ \text{cp})}{175} = 87.2$$

For curve 2

$$kh = \frac{(162.5)(684\ \text{B/D})(1.00)(0.35\ \text{cp})}{275} = 141.4$$

Thus the value of kh is greater for the reservoir during the injection operations than during the production operations. Apparently this indicates a change in effective water permeability in the watered-out region.

The difference between the observed injection pressure and the theoretical injection pressure is a measure of the skin effect. A positive difference indicates the

pressure drop that is consumed in overcoming the skin. A negative difference would indicate higher permeability in the wellbore vicinity than in the reservoir. An example of the calculation of skin effect at the time of shut-in for curves 1 and 2 is illustrated below. Equation 4 was used to calculate the theoretical pressures (change sign of right hand member of the equation when calculating the flowing pressure $P_{r_{wf}}$). Symbols and their units are listed in the Nomenclature section.

Status of Well	Producer	Injector
P_s (from curve 1 or 2)	2,370 psia	2,370 psia
Q_s	263 B/D	684 B/D
F	1.02	1.00
kh (from curve 1 or 2)	87.2 md-ft	141.4 md-ft
h (from electric log)	108 ft	108 ft
k	0.81 md	1.31 md
r_w	0.411 ft	0.411 ft
f (core analysis)	0.22	0.22
μ	0.35 cp	0.35 cp
c	1.59×10^{-5} psi^{-1}	1.59×10^{-5} psi^{-1}
t_c	989 hr	622 hr
$P_{r_{wi}}$ (from Equation 4)	—	4,123 psia
$P_{r_{wf}}$ (from Equation 4)	1,256 psi	—
P_f (observed)	78 psia	—
P_i (observed)	—	4,185 psia

Skin during production $= P_{r_{wf}} - P_f = 1{,}178$ psi

Skin during injection $= P_i - P_{r_{wi}} = 62$ psi

The skin effect was considerably greater during production than during injection. Apparently the skin effect which prevailed during production has been overcome by the conditioning operations used in converting the well to injection and possibly by the injection operations. On the basis of the foregoing analysis, it was demonstrated that well A-1 is taking water at approximately maximum rate at prevailing injection pressures, and any remedial work designed to increase the rate at this time is not necessary.

In making the foregoing calculations, a question may arise as to the source of the numerical values of such parameters appearing in Equation 4 as the net sand thickness h, the porosity f, and the compressibility of the fluid-reservoir system c. All of these parameters enter directly or indirectly into the last logarithmic term of Equation 4. Hence, considerable latitude in their values can exist before noticeable effects are observed in the calculated value of $P_{r_{wi}}$. The value of h must be known to calculate the effective water permeability. It is usually obtained from an electric log or preferably from an injectivity profile. The value of f is obtained from core analysis. The value of c includes the compressibility of water, oil, gas, and the reservoir rock. At best it can only be approximated. For example, for well A-1 it was established from material balance calculations that no free gas saturation is present in the formation. Then the compressibility is equal to $c = S_w c_w + S_o c_o + c_r = 1.59 \times 10^{-5}$ psi^{-1}, where S_w and S_o are the water and oil saturations equal to 70 and 30 per cent, respectively, and where c_w and c_o are the coefficients of compressibility of water and oil equal to 0.33×10^{-6} psi^{-1} and 1.55×10^{-5}psi^{-1}, respectively. The value of the rock compressibility was obtained from laboratory studies on cores under conditions wherein the overburden pressure was varied on the core while maintaining static reservoir pressure in the pores of the core. The compressibility was found to be equal to 0.9×10^{-5} psi^{-1} or about three times as great as the compressibilty of water.

It is of interest to note that by using the numerical values listed above, a theoretical pressure fall-off curve can be calculated from the precise Equation 5. This has been done for well A-1 to determine how closely the curve, calculated from physical data obtained from several sources, approaches the observed curve and to establish the minimum shut-in time at which the approximate Equation 7 gives the same value of P_{r_w} as that obtained by the precise Equation 5. In Fig. 1, curve 3 is the calculated curve from Equation 5. It coincides with the section III of the observed curve, but it does not contain a section that is equivalent to section II of the observed curve because the skin effect is not analytically defined by the equation. From the point of deflection of the curve it is evident that for shut-in times greater than 10 seconds the curve assumes a straight line that coincides with the straight line as predicted by Equation 7.

General Characteristics of Pressure Fall-Off Curves

In Fig. 2, curves 1, 2 and 3 illustrate the variation in the shape of the wellhead pressure fall-off during the injection history for well A-1, field A. The curves were obtained at two-month periods during which the injection rate was held approximately constant. It will be observed that the injection pressure increased with time; hence, the curve for each succeeding period is displaced upward from the preceding one; however, the later shut-in portion of the curves fall on the same line. Analysis of the early shut-in portion of the curves reveals that the observed increases in the injection pressures were greater than those theoretically predicted. Apparently gradual plugging of the formation face by the materials in the injection water was occurring with time. Analysis of the latter shut-in portion of the curves reveals that insufficient volume of water was injected to cause noticeable increase in static reservoir pressure.

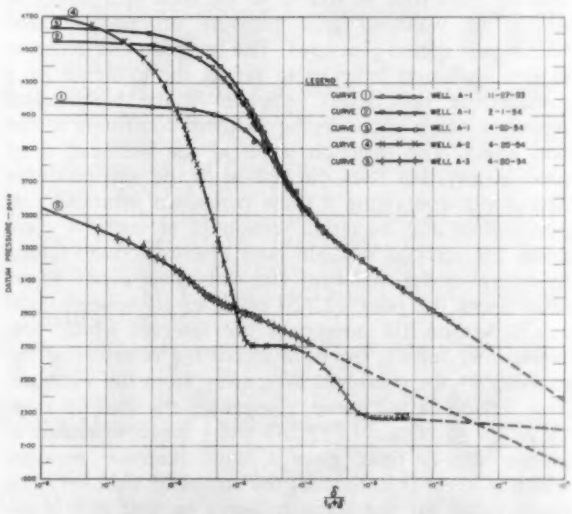

Fig. 2 — Pressure Fall-off Performance of Wells A-1, A-2, A-3, Field A. Well A-3 is Separated by a Fault from Wells A-1 and A-2.

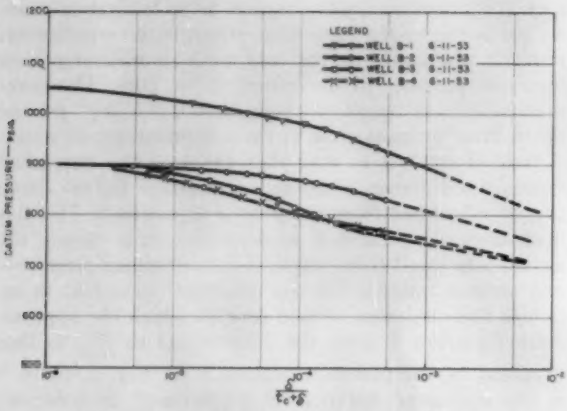

FIG. 3—WELLHEAD PRESSURE FALL-OFF PERFORMANCE OF FOUR WELLS IN A FIVE-SPOT PATTERN, FIELD B. REMARKABLE UNIFORMITY IN THE STRATIGRAPHIC SECTIONS EXISTS AMONG THE WELLS

Also illustrated in Fig. 2 are the differences in the general characteristics of pressure fall-off curves obtained on three wells: well A-1, well A-2, and well A-3. These wells are completed in the same field and zone but in different portions and intervals of the zone. They are located in the peripheral region of the field and are completed in a thick zone which is comprised of interspersed sand, silt, and shale strata of varied oil, gas, and water productive capacities. There is some reason to believe the portion of the zone in which well A-3 is completed is separated by a fault from the same zone in which wells A-1 and A-2 are completed. Hence, the curve for well A-3 extrapolates to a different static pressure than that for the curve for well A-1.

The curves for wells A-3 and A-1 (Fig. 2) illustrate the shape of pressure fall-off curves resulting from data obtained at the wellhead for shut-in periods lasting up to 10 hours. Curve 4 (Fig. 2) for well A-2 illustrates the shape of the pressure fall-off curve obtained at the datum depth with a bottom-hole pressure bomb for an 80-hour shut-in period.

For interpretation purposes, curve 4 can be split into four general sections. The first section includes the interval from time of shut-in to the time (0.5 hour) at which the wellhead gage pressure dropped to zero (2,720 psia datum pressure). The rapid decline depicted in this section is believed to reflect the existence of a considerable skin effect. Apparently the biochemical reactions which occur in the wellbore contribute to the skin effect. The injection water at the wellhead is of good quality, but back circulation of the well produces dark water containing a slime composed principally of iron sulfide and bacteria. Section II of curve 4 comprises the interval wherein both after-injection (falling fluid level in the wellbore) and skin effect occur. It extends from 0.5 hour (2,720 psia) to 16 hours (2,300 psia). Section III comprises the interval which predominantly reflects the behavior of the reservoir in the majority of the pressured area away from the wellbore. This section of the curve, comprising the interval from 16 hours to 60 hours (2,265 psia) when extended to infinite shut-in time, gives a static reservoir pressure which is lower than that for the curves of well A-1. The lower value for the static pressure in well A-2 is expected, inasmuch as the well is completed in the upper portion of the zone, whereas well A-1 includes a substantial portion of the lower zone as well. It will be noted that at the end of section III a gradual pressure build-up occurs. This is believed to reflect the effect of interference from well A-1 which was under injection during the shut-in period of well A-2.

In Fig. 3 are shown wellhead pressure fall-off curves obtained on four wells in a five-spot pattern in a California reservoir, designated here as field B. The reservoir is characterized by a remarkable uniformity in the stratigraphic sections among the wells. The gross zonal interval is 160 ft thick, consisting of three oil bearing strata separated by shale bodies, wherein the areal uniformity of the oil sand is excellent. All wells were completed using clean field brine as the drilling fluid. The injection rates are maintained approximately equal for the four wells. Analysis of the curves indicates low permeability sand and negligible presence of the skin effect.

In contrast to the data of Fig. 3, in Fig. 4 are shown wellhead pressure fall-off curves obtained on four wells in a five-spot pattern in a relatively thin reservoir, designated here as field C, wherein large lateral gradations of lithology and permeability exist. Wells C-2 and C-3 are completed in the area of the zone where a 4-ft thick stringer of 1,500 md air permeability occurs at the bottom. The remainder of the zone has a permeability range of 0-150 md. Wells C-1 and C-4 are completed in the area of the zone where the high permeability stringer is absent and the zonal permeability ranges from 0-150 md air permeability. Approximately equal injection rates are maintained on the four wells. The curves in the figure were obtained after one month of steady injection. It is evident that for wells C-2 and C-3 the pressure declines more rapidly than for wells C-1 and C-4. Field surveys established that in each of the wells, the hole is filled with shale sloughings to about the midpoint of the zone. It is believed that the more pronounced pressure decline in wells C-2 and C-3 reflects the effect of skin caused by the shale fill over the high permeability stringer. The shut-in data are not of sufficient duration for the four wells to reflect adequately the conditions in the reservoir area around the wells.

CONCLUSIONS

From the mathematical analysis of pressure fall-off data obtained when a water input well is shut in, it has been demonstrated that the reservoir pressure, the

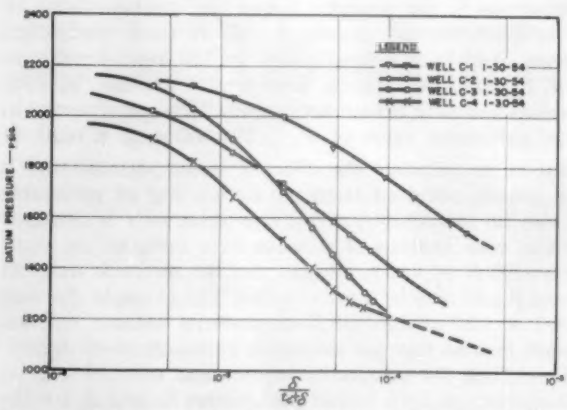

FIG. 4—WELLHEAD PRESSURE FALL-OFF PERFORMANCE OF FOUR WELLS IN A FIVE-SPOT FLOOD PATTERN, FIELD C. LARGER LATERAL GRADATION OF LITHOLOGY AND PERMEABILITY EXIST IN THE FIVE-SPOT.

potential injective capacity of the formation, and the degree of formation damage in the immediate vicinity of the wellbore can be estimated.

To obtain pressure fall-off data that is suitable for the analysis, the following precautions must be observed: (1) the well must be stabilized prior to shut-in by maintaining continuous and constant injection rate for a period of about one week or more; (2) upon closing in the well, a positive shut-off must be obtained at the surface; and (3) the shut-in period must be of sufficient duration in order that a section of the pressure fall-off data will be obtained which predominantly reflects the behavior of the reservoir in the majority of the pressured area away from the well.

In the analysis of pressure fall-off curves, considerable judgment must be exercised in choosing the correct section of the curve from which the computations are to be made. For reservoirs which behave as if they were of infinite areal extent, this section is a straight-line curve obtained during the latter stages of shut-in time.

Because the pressure fall-off curves can be interpreted in terms of the injective capacity and the formation damage, they can be used in investigating benefits that might be obtained through application of remedial measures. The resulting benefits of remedial measures are directly determinable.

The analysis of pressure fall-off curves is based on several assumptions which tend to limit its general applicability. Notable among the assumptions are those pertaining to the infinite size of the reservoir and to the uniformity of the permeability in the reservoir. Data obtained in the early stages of the injection history will satisfy the assumption dealing with the size of the reservoir. It is believed that the analysis of pressure fall-off curves is applicable even to formations comprised of several sand strata of permeabilities ranging from tight sands to highly permeable sands. However, further testing in practice is required in order to determine the usefulness of the method and its limitations under various field conditions.

ACKNOWLEDGMENT

Concurrent with the time of presentation of this paper, a similar treatment but an independent approach for analyzing pressure fall-off curves by Joers and Smith has been published.[13]

The authors wish to express their appreciation to J. E. Sherborne, R. S. Crog, and M. G. Arthur for their suggestions and assistance and to thank the Union Oil Co. for permission to publish this paper.

NOMENCLATURE

c = coefficient of compressibility of the fluid-reservoir system, psi^{-1}
c_o = coefficient of compressibility of oil, psi^{-1}
c_r = coefficient of compressibility of rock, psi^{-1}
c_w = coefficient of compressibility of water, psi^{-1}
Ei = the exponential integral function:

$$Ei(-x) = -\int_x^{\infty} \frac{e^{-u}}{u}\, du$$

e = the exponential constant (2.718 · · ·)
F = formation volume factor, reservoir barrel per stock tank barrel
f = porosity, a fraction
h = net thickness of formation, ft
k = effective permeability of formation, md
ln = logarithm to base e
log = logarithm to base 10
P_i = observed wellbore injection pressure, psia
P_f = observed wellbore production pressure, psia
P_r = formation pressure at point r from the wellbore axis, psia
P_{r_w} = pressure in wellbore, psia
$P_{r_{wf}}$ = calculated flowing wellbore pressure, psia
$P_{r_{wi}}$ = calculated injection wellbore pressure, psia
P_s = static reservoir pressure, psia
Q = rate of injection, assumed constant, B/D
Q_s = established injection rate before closing in the well, B/D
r = distance from wellbore axis, ft
r_w = radius of wellbore, ft
S_o = oil saturation, a fraction
S_w = water saturation, a fraction
t = time (measured from time zero at moment of start of injection), hour
t_e = pseudo-time of injection, hour, defined by

$$t_e = \frac{\text{total volume of water injected}}{\text{rate of injection just before shutting in}}$$

U = argument of the Ei-function equal to $\dfrac{948.2\, r^2 f \mu c}{k\, t}$
δ = time elapsed since closing in the well, hour
μ = viscosity, cp

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Membership Directory

of the

PETROLEUM BRANCH

AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS, INC.

JUNE 1955

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Oklahoma City Section. Meets at noon on third Thursday each month in Oklahoma City. H. D. Christner, *chairman;* R. B. Chapman, *first vice-chairman;* G. E. Saunders, *second vice-chairman;* Don Phelps, *secretary-treasurer. Executive Committee: R. K. MacIvor, Walt Pearson, Joe Maly.*

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The drilling department insists on emulsion mud...

The geological department says "NO!"

This was no friendly argument—it was a red hot rhubarb! To reduce hole deviation and to increase rate of penetration in this wildcat well, the drilling department had run bigger and heavier drill collars in a 10⅝" hole. With 6 to 8 collars (45 ft. long, 9½" diameter stabilized out to 10⅝"), weight on the bit was around 40,000 to 50,000 lbs. (Some operators even carry up to 110,000 lbs. depending upon bit size.)

It is common knowledge that crooked hole problems decrease as collar size increases—less chance for wobble. Dog legs are less severe and more weight on the bit makes hole faster. But small clearances appreciably increase dangers of sticking and should large diameter collars get stuck, man, you're in real trouble! There is no room to fish or wash over.

To take every precaution, the drilling department insisted on an emulsion mud. It slicks up the hole, reduces drill pipe torque, deposits a thin oily mud cake that lessens the hazards of wash outs, minimizes shale problems, usually speeds up drilling rate, and definitely lowers the chances of getting stuck.

The geologists objected to emulsion mud on the grounds that the oil in the mud would interfere with the analysis of cores and cuttings, which is exactly what it used to do before the advent of NO-GLO OIL. Evidences of fluorescence or a stained cut under the black light may come from the mud rather than from the formation—how can you be sure?

They finally agreed on NO-GLO* OIL, since it would satisfy both of their needs. NO-GLO OIL is a colorless, non-fluorescing, specially refined oil which may be added to a clay-water mud in the normal manner, and which *does not fluoresce even under high well temperatures and long aging.*

Shortly after setting surface pipe, they went to a NO-GLO emulsion mud and avoided any serious trouble thereafter. The Division Manager claims that the mud saved setting a $40,000 protective string of casing because the drilling department was unwilling to carry an excessive amount of open hole in this deep test without the benefit of oil in the mud. The geologists encountered no difficulties in accurately interpreting cores and samples. The non-fluorescing mud met all the requirements of a good drilling fluid to everyone's mutual satisfaction.

In many exploratory wells NO-GLO OIL has been successfully used in place of crude oil for spotting to release stuck pipe. Recent extensive tests by a major operator prove that a high gravity refined oil is superior to crude oil for this purpose. Costs of marketing NO-GLO OIL have been substantially reduced; in some areas it is priced but slightly higher than diesel oil. Write for complete information.

*U.S. Patent 2,698,833

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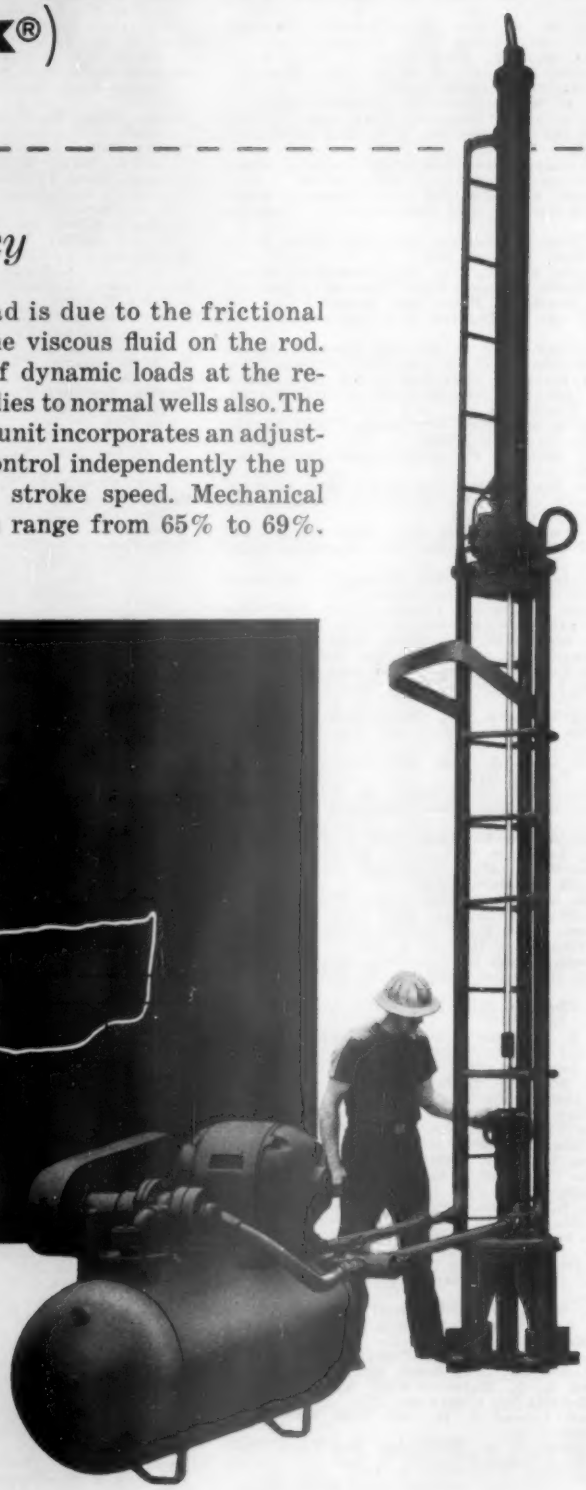

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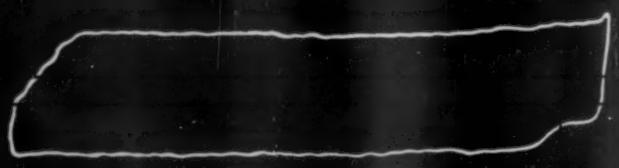

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Write for "Hydrax" Bulletin No. 5400-P and Long Stroke Bulletin No. 5305, which give complete technical explanation of operation and advantages of these units.

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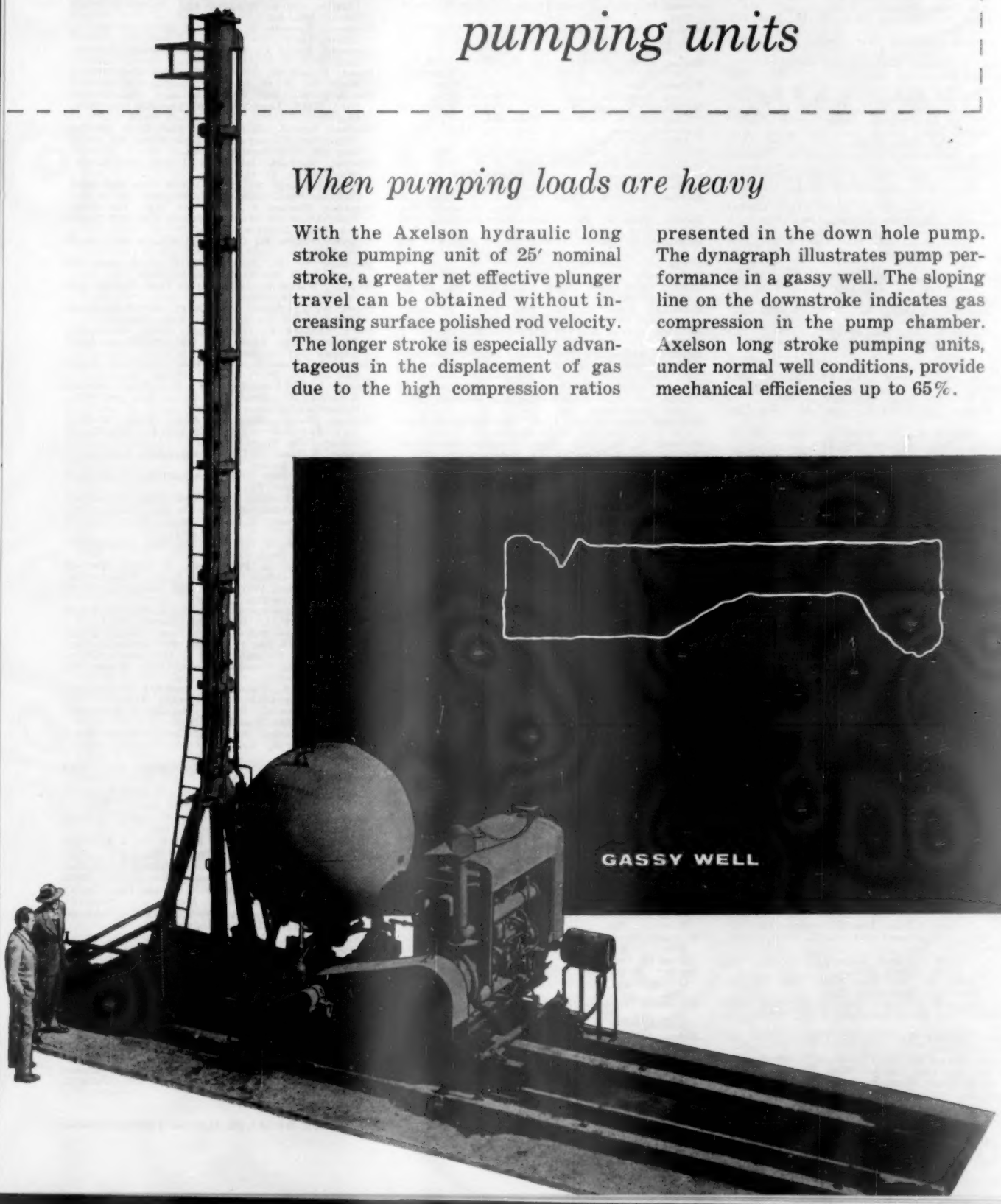

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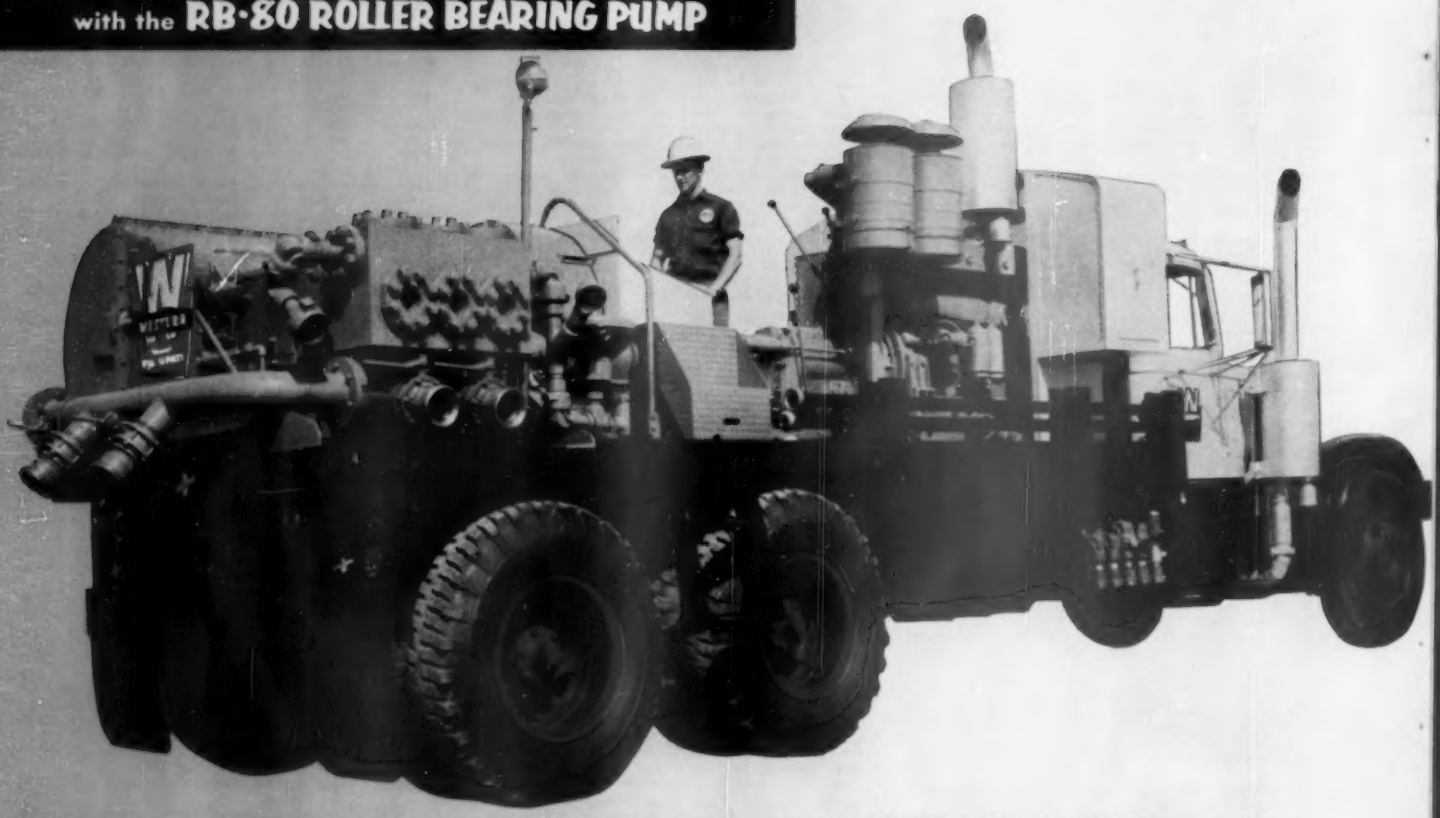

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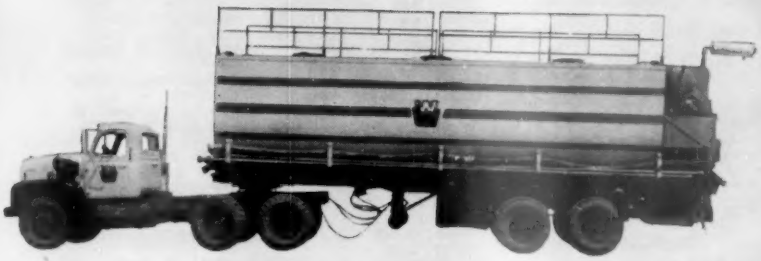

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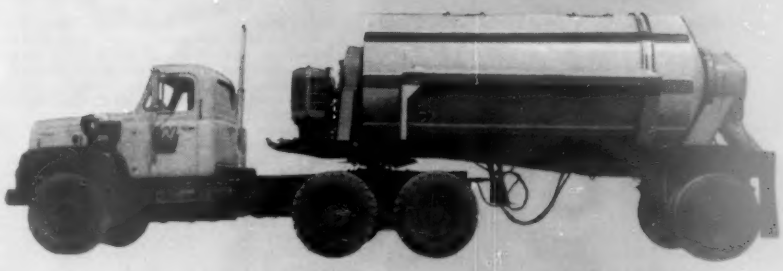

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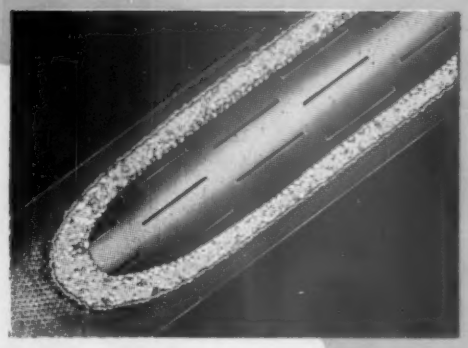

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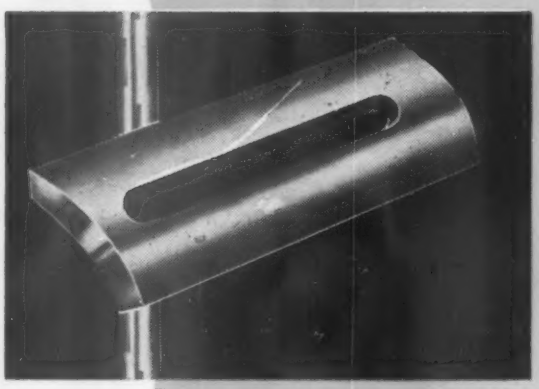

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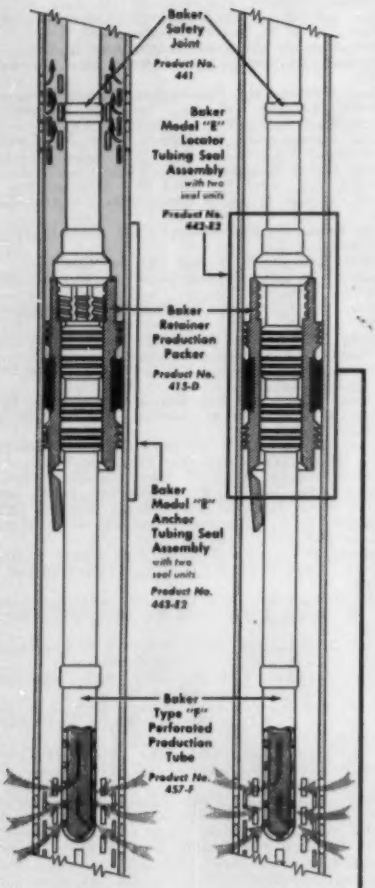

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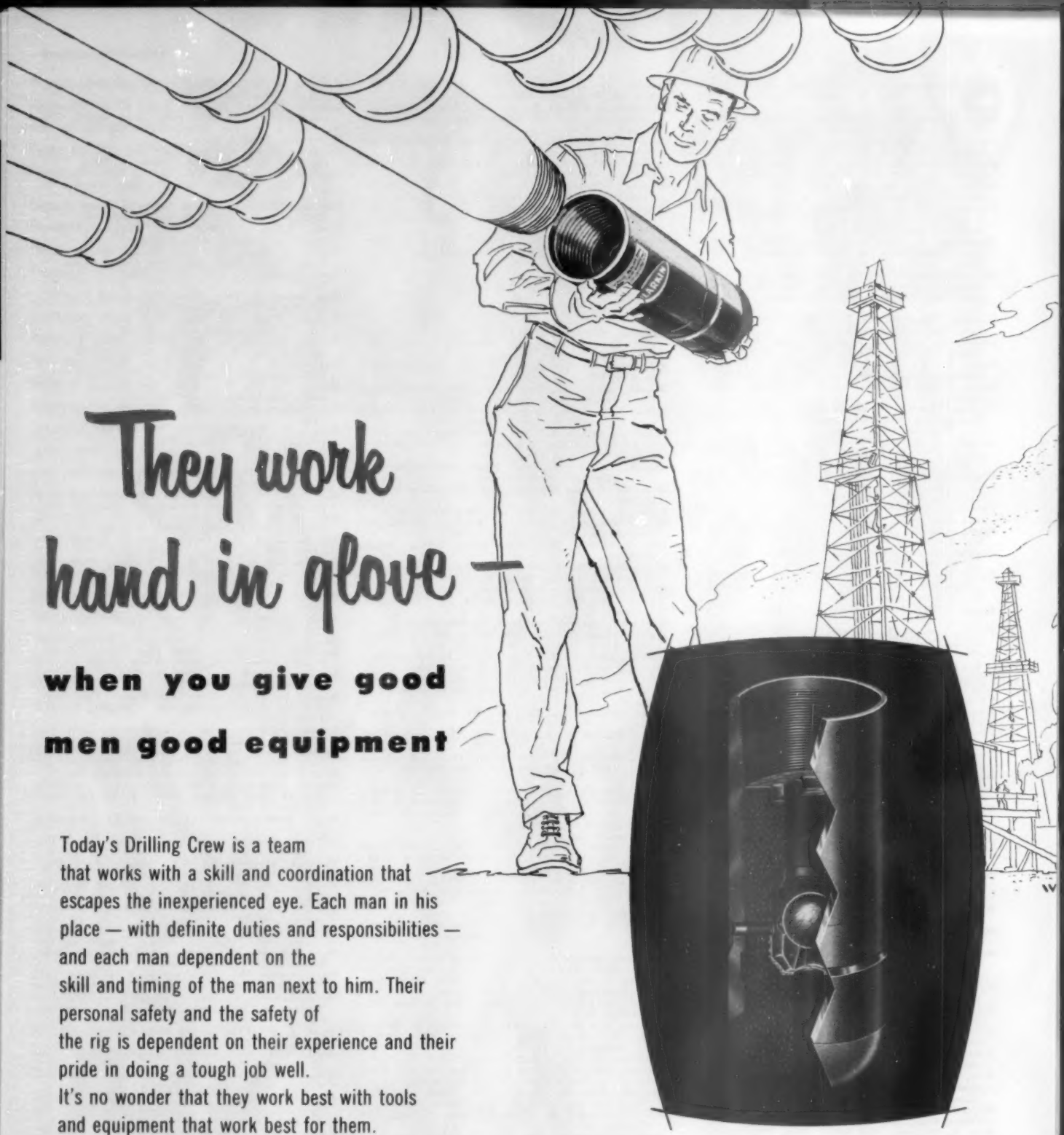

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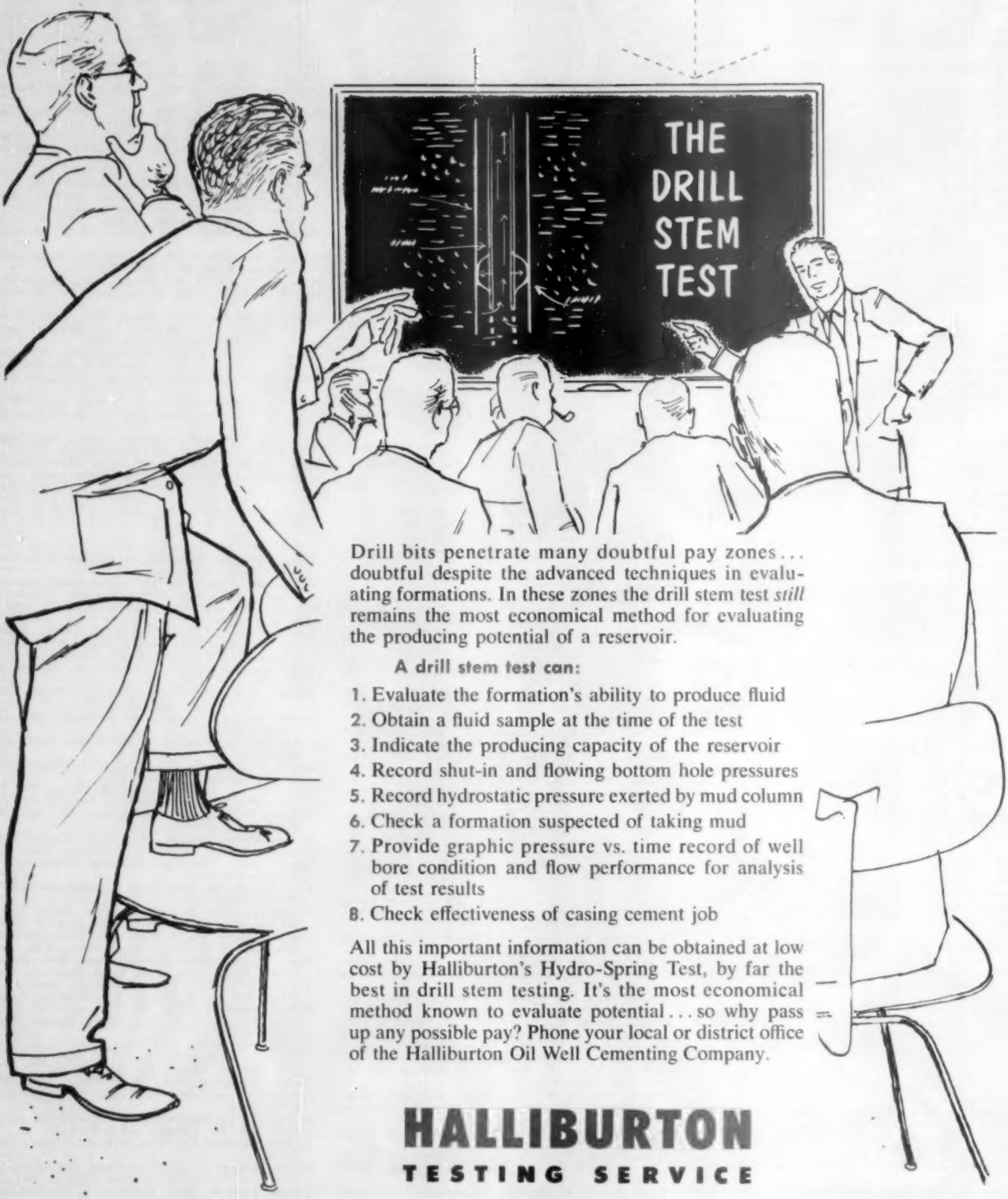

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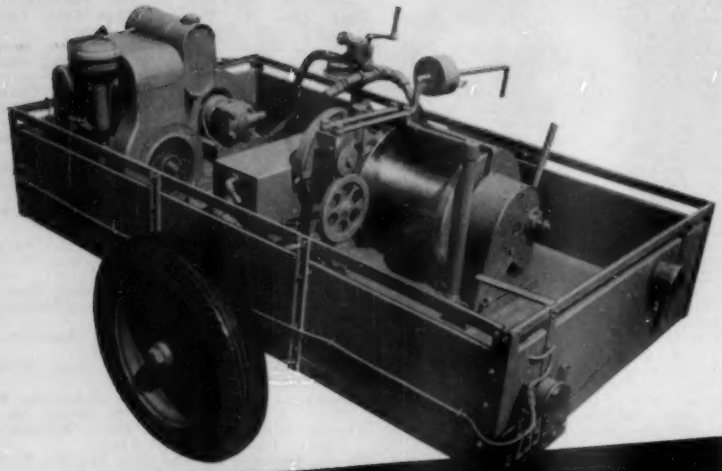

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Edwards, James M.
Eggleston, W. S.
Elliott, Joseph C.
Ellis, J. H. Northrop
English, Walter A.
Erskine, Kenneth, Jr.
Evert, Don E.
Fernandes, Robert J.
Field, A. J.
Fisk, Edward P.
Flack, Sloan
Forsyth, Val L.
Foss, Daniel L.
Foss, R. E.
Foy, Frederick P., Jr.
Gates, Charles F.
Gates, John I.
Gay, George M.

Los Angeles—*Continued*
Geis, W. H.
Gentry, Albert W.
Godfrey, William Kerr
Goode, Ben H., Jr.
Grant, Charles D.
Graybeal, Oran A., Jr.
Green, W. R.
Greene, R. G.
Gregory, James N.
Greutert, Raymond H.
Griffith, Clayton O.
Grinsfelder, Sam
Gutschow, Nathan R.
Hahne, Werner H. E.
Hake, Benjamin F.
Hamner, Edward J.
Hanson, Ralph T.
Harke, Robert Emil
Harris, Richard C.
Haseltine, Oran L.
Hassler, Gerald L.
Heath, Ronald W.
Hepburn, G. C., Jr.
Higgs, Morton T.
Hills, John O.
Hollister, Harold B.
Holman, Richard A.
Hughes, James D.
Hutcheson, Robert Bellenden
Ingels, Raymond M.
Irwin, Emmett M.
Jappay, David Walter
Jensen, Joseph
Johnson, Alva M.
Johnson, Bernard R.
Johnston, Daniel S.
Johnston, Elizabeth J.
Johnstone, Donald I.
Johnstone, Edward B.
Jones, John Alexander
King, Vernon L.
Kingman, Douglas G.
Kinnie, John R.
Kline, Mortimer A.
Klipp, James E.
Knudsen, John, Jr.
Koch, Donald E.
Kunzi, Robert E.
La Bouff, John J., Jr.
Langton,, Arthur
Larsen, Delmar H.
Ledingham, Glen W.
Lee, Francis L.
Lewis, Milton W.
Liedholm, Clarence C.
Lockwood, R. Bruce
Loy, Milton E.
Lung, John D.
Macready, George A.
Marsh, Hallan N.
Matheny, Shannon L., Jr.
McCloskey, Downs
McCoy, William B.
McKinnon, Murray C.
McMillan, John R.
McNeill, James Michael
Mendoza, Joseph J.
Merritt, Floyd C.
Metzner, Loyde H.
Miller, J. Charles
Miller, Robert P.
Minckler, R. L.
Misbeck, Robert J.
Moberg, A. R.
Moberg, A. R., Jr.
Morris, Lawrence K.
Morris, William L.
Morton, Harold C.
Morton, Tom E.
Mull, Bert H.
Neale, John J.
Newman, James L.
Nichols, John H.
Nilsson, George W.
Nissen, Harold E.
Noble, Earl B.
Norris, William F.
Nutter, Donald S.
O'Bert, Lawrence K.
Oliver, Graydon
Olsen, Harold T.
Otis, Russell M.
Park, Stafford
Parker, Frank Stephen
Parks, Ernest K.
Parsons, Benjamin Everett
Parsons, Claude P.
Patterson, Sam A.
Pemberton, John R.
Peters, E. F.
Pfaffman, George A.
Porter, Frederick C.
Porter, Lawrence E.
Porter, William W., 2nd
Purmort, Louis Edward
Pyle, Howard C.
Pyles, Ernest E.
Ratcliffe, George L.
Reinhardt, W.
Riegle, John, Jr.
Riordan, Mathew B.
Ritchie, Kenneth S.
Roberts, Claudius H. M.
Rodriguez, Sergio E.
Roper, William N.

Los Angeles—*Continued*
Rubel, A. C.
Schaller, Herman E.
Schoonover, Floyd E.
Scott, William J.
Seykota, Harold R.
Sheldon, Theodore D.
Sheldon, Walter C.
Sheppard, James C., III
Six, C. W.
Slattery, Harry W.
Smith, Richard Hale
Soden, Archie D.
Solum, James R.
Soper, E. K.
Sowards, George
Stanier, Harold M.
Steiner, Edward M.
Stephens, John L.
Stephens, R. Joe
Stewart, James S.
Stick, John C., Jr.
Stipek, Raymond .
Stolz, Fred C.
Stolz, Harry P.
Stone, Reid T.
Stormont, David H.
Straitiff, Dorsey E.
Stream, Harold H., Jr.
Swayze, Ronald O.
Taves, Max J.
Taylor, Reese H.
Tempelaar-Lietz, W.
Templeton, R. R.
Terry, Paul E.
Thomas, Gerald B., Jr.
Trankle, Brian F.
Valentine, William W.
Van Dyke, Gilbert R., Jr.
Vaughan, K. C.
Vlack, R. C.
Wadsworth, F. L.
Walker, E. Wilfrid
Walker, James Murray
Walker, Richard A.
Wallace, Thomas H.
Walling, Rolla W.
Walters, William C.
Wardner, William R., Jr.
Watson, Cresap P.
Weber, John G.
Wedemeyer, Roland C.
Weeks, Harold E.
Weigand, Walter J.
Wells, George R.
Whealton, R. G.
White, B. L.
White, J. Lloyd
White, Robert T.
Whiting, Dwight
Winterburn, Read
Wright, Fay L.
Young,. Garth L.
Young, Vernon R., Jr.
Yuster, S. T.
Zublin, C. William
Zublin, John A.

Maricopa
Bush, William E.

Menlo Park
Crooker, John T.
Stearn, Noel H.

Modesto
Hockman, A. B.

Montebello
Johnston, Norris
Lampkin, Robert E.
Schuyler, Peter Treat

Monterey Park
Dietzel, Norman E.

New Cuyama
Davis, Chester A.
Scranton, James M.

Newhall
Barbarick, Harding
Evans, Charles B.
Ferguson, Hobart D.
Hendrix, James W.
McDonald, John O.
Thompson, Gene D.
Timm, Robert W.

Newport Beach
Dodge, John Franklin

North Hollywood
Cabeen, William R.

Norwalk
Higgins, Robert E.

Oakland
Gaylord, E. G.
Laird, Raymond T.

Ojai
Christianson, P. L.

Orcutt
Adams, John
Bickmore, David K.
McCullough, Joe J.
Thompson, Lloyd F.

Oxnard
Stehle, Carl V., Jr.

Pacific Palisades
Leichliter, Otto G., Jr.

Palos Verdes Estates
Radcliffe, Donald Hewson
Tizard, William E.

Palm Springs
Bransford, James C.

Palo Alto
Brooke, J. K.
Brown, Robert Wesley

Paramount
Allen, William J.
Baker, J. Shannon
Hoffman, Dean R.

Pasadena
Alder, Robert Lee
Arnold, James C.
Bailly, Florent Houlding
Brittain, John
Cerf, Charles J.
Christie, James B.
Moran, Robert B.
Nickell, Frank A.
Sage, B. H.
Simmons, Edward E., Jr.
Sohlberg, R. G.
Stauffer, Clinton R.
Vaughan, Francis Edward

Playa Del Rey
Treadwell, Harry A.

Redlands
Jahn, Gustave A.

Reseda
Basenberg, Cecil O.

Riverdale
Gibson, Lee W.

Rolling Hills
Graner, Jesse B.

Sacramento
Cox, Ralph Frank

West Sacramento
Coombs, Stanley E.

San Francisco
Adams, E. E.
Ambler, Richard H.
Blunden, Richard L.
Bowman, Richard J.
Bowman, Robert B.
Bristow, Arthur B., Jr.
Brown, John S.
Brunel, Louis J.
Bujol, Wallace C.
Cadle, Austin
Cassell, John K.
Cluck, Charles E.
Cole, Fraser M.
Cranson, Lorin A.
Decius, L. Courtney
Dolbow, Philip G.
Evans, Barry Louis
Eyssell, James H.
Fairlie, Philip G.
Forrester, Emmett, Jr.
Gester, G. C.
Goodwill, David
Gosline, James E.
Grinstead, W. Carter
Harms, James Edward
Hartook, E. A.
Hertel, F. W.
Higgins, Ralph V.
Jones, Dan M.
Kew, William S. W.
Klemme, Herbert A.
Lakenan, Cornelius B.
Lindsay, James Edward
Little, Don Dale
Loomis, Albert G.
Mattei, A. C.
McCloskey, Downs, Jr.
McCroden, Thomas J.
Mein, William Wallace, Jr.
Miller, H. C.
Miller, J. M.
Miller, Thomas Norwood
Mixon, Robert B.
Moncrief, Charles M.
Murdock, Roy K.
Musser, Edgar H.
Nicholson, Ralph C., Jr.
Reith, Colin W.
Russell, Edward L.
Russell, Ralph Harrison
Shea, G. B.
Standing, Marshall B.
Stults, Delwin C.
Swartz, Henry J.
Thacher, John H., Jr.
Toussaint, Jules E.
Turman, Arthur F.
Vogt, Ernest A.
Wishart, George C.

San Gabriel
Graser, Frederick A.
Schwab, James W.

San Leandro
Allen, R. Dean

San Marino
Harris, Jerry L.
Wagner, Edmond M.
Webster, Mark B.
Woodward, A. F.

San Pedro
Farrow, John R.
Larson, W. Edward

Santa Cruz
Ham, T. Fenton

Santa Fe Springs
Frisius, Edward N.
Heintz, Louis O.
Suter, Vane E.

Santa Maria
Elliott, Myron R.
Randall, Arthur G.
Severns, Jack R.

Santa Monica
Sabin, Edward B.

Santa Paula
Borkovich, George J.
Lester, Graham W.
Livesay, Robert B., Jr.
Schleimer, James A.
Wade, F. Russell

Santa Rosa
Horton, H. M.

Saticoy
Barley, Kemp E.

Saugus
Shepard, H. L.

Seal Beach
Biren, Jack A.
Fielding, Herbert L.

Shafter
Norton, Craig R.

Sierra Madre
Austin, M. D.

South Gate
Kazarian, Bob
Parsons, Wm. K.

South Pasadena
Burns, James
Law, Jan
Sheldon, Dean H.
Smith, Lyle W.
Wingen, N. Van

Stanford
Ambler, Alan Charles
Deeter, Jack N.
McCleary, Urie, Jr.
Miller, Frank George
Tickell, Frederick G.

Taft
Adams, Richard H.
Aseltine, Richard J.
Cramer, T. Dudley
Dobeck, Howard R.
Doepel, George W.
Dunbar, Walter L. M.
Eardley, Wendell A.
Gallear, Darrell C.
Henderson, A. D., Jr.
Horn, A. J.
Hutchison, Stanley O.
McGriff, John Patrick
Meaney, Daniel
Oliphant, J. J.
Putnam, Murray
Sepaspour, Mahmoud
Standley, Eugene W.
Strong, William R.
Van Wyke, Jack
Williams, Leon
Waldner, C. E. De La Garde
Walker, John Wesley
Wankowski, Victor O.
Wilson, Warren T.
Wyman, Thomas S.

Torrance
Bernt, Daniel M., Jr.
Green, Laurence A.
Green, Russell Hamilton, Jr.

Tupman
Finical, Thomas N., Jr.
Maver, Edward H.
Slick, Normand E.

Van Nuys
Humhpreys, David W.
Seaman, W. H.

Ventura
Andersen, Jack F.
Arthur, J. L.
Bates, William F.
Eastin, Bertrand
Fehrenbach, Joseph R.
Ghauri, W. K.
Jarrett, James C.
Larson, Robert R.
McClellan, Hugh W.
Monson, Charles E.
Schuppert, Richard R.
Stafford, Robert W.
Swiers, Donald G.
Teitsworth, Robert A.
Van Riper, John

Vernon
Reekstin, Robert W.

Waseo
Tinsley, Arthur Bynum

Whittier
Aker, Jimmin R.
Alber, John L.
Bauer, Robert F.
Carlisle, Frederick M.
Cerini, Wililam F.
Cheyney, George R.
Cook, Phillip G.
Ewing, Hunter Halliday
Faull, R. Francis
Forte, Everett L.
Fraser, John R.
Gardiner, Chester M.
Govreau, Fred H.
Graves, Doyle T.
Kline, James M.
Ledbetter, J. T.
MacLean, Alan M.
McMurry, Thomas R.
Nowak, Ted John
Pedretti, Juan P.
Roberts, Sanford M.
Wade, Vance A.

Willows
Griffin, Will C., Jr.

Wilmington
Hamann, Paul M.
Janke, Paul A.
Savoy, Basil V.

COLORADO

Ault
Hill, Joseph P.

Aurora
Waters, Kenneth H.

Boulder
Hares, Charles J.
Pollard, J. Frank

Center
Ellsworth, Don L.

Colorado Springs
Bucher, Frederick J.
Magruder, James A.
Shoup, Merrill E.
Van Horn, Harold G.
Wood, Fred E.

Craig
Ladd, J. Bertram

Cripple Creek
Keener, James

Denver
Albert, Robert O.
Alexander, W. A.
Angevine, Robert H.
Banister, John A., Jr.
Baxter, Robert C.
Berry, George W.
Binkley, John F.
Bischoff, Robert M.
Bledsoe, Joel C., Jr.
Bosco, F. N.
Bowman, Joseph S.
Bretschneider, Herman C.
Brokaw, Chas. A.
Brown, Donald F., Jr.
Bryan, W. E.
Burke, Billy F.
Cameron, Charles V.
Carter, Anthony J., Jr.
Chabas, Paul D.
Christianson, E. G.
Clark, Charles C.
Collins, Ralph W.
Conaway, Don W.
Cooke, Robert S.
Crawford, David M.
Curtis, Ralph D.
Dimit, Charles E.
Dobbin, C. E.
Dunlap, Eldon N.
Elton, Frederick William
Fackler, William C.
Fairchild, Paul W.
Fentress, George H.
Ferry, John Huntington
Frazier, Roger S.
Funk, Norman W.
Glenn, Wayne E.
Goodier, William R.
Gore, Georgg Louis
Grimes, Harold N.
Grimm, Paul E.
Hall, J. W.
Hansell, James M.
Harris, James D., Jr.
Harrison, Thomas S.
Harvey, Arthur
Hester, Leroy Vance
Hiestand, T. C.
High, Harper A.
Hill, Robert C.
Hogan, Thomas M.
Holland, Alfred A.
Hols, A.
Hoss, Robert L.
Jackson, John Gordon
Jennings, John H.
Kauffmann, Howard C.
Klaeger, Edward J.
Lay, Patterson
Lebsack, Milton J.
Leonard, Woodrow W.
Loy, Max S.
Marshall, John
Mattson, T. O. H.
Maxey, Carl L.
McKnight, C. R.
Merrion, J. Gregory
Mitchel, Theodore S.
Moore, John H.
Morazzani, Alan
O'Boyle, Charles C.
Owens, Marvin F., Jr.
Padboy R. S.
Paine, Samuel M.
Pearl, Ward C.
Polumbus, Emile A., Jr.
Porter, V. B.
Porter, W. E.
Prior, Frank O., Jr.
Pugh, William L.
Pustmueller, Paul S.
Rabe, Charles L.
Ray, C. J., Jr.
Reagan, Thomas
Reneau, George H.
Richardson, Everett E.
Robineau, Maurice H.
Rosenthal, Chas. A.
Rousselot, Norman A.
Sebastian, Daniel H.
Selim, M. A.
Shannon, Richard S., Jr.
Shapiro, Robert
Sheppard, Keith D.
Sloss, James P.
Smith, William R.
Sneed, Robert W.
Stalcup, Obie L.
Stein, John E.
Storm, Lynn W.
Stottlemyer, Robert D.
Stovall, William Stuart, Jr.
Thomas, Henry E.
Thompson, Donald W.
Trueblood, Harry A., Jr.
Tynan, John W.
Uhrlaub, James A.
Vitt, Alfred W.
Vogenthaler, Thomas J.
Walker, Robert L.
Waltman, Reid M.
Wieder, A. H.
Wilcox, Charles R.
Wilson, C. V.
Worth, Dale R.

Durango
Lauth, R. E.
Loos, De Lasso

Englewood
Robinson, Ernest Guy

Ft. Collins
Anders, Sidney D.

Fort Morgan
Evinger, John H. N.

Golden
Beers, John R.
Boyce, Charles James
Coady, A. B.
Dutton, William G.
Fails, Thomas Glenn, Jr.
Fernstrom, John B.
Frederickson, Albert Earl
Halstead, Phil
Hollister, John C.
Irwin, Joe Jr.
Keleher, Jerry
King, Hugh
McCall, Donald L.
McGlone, Allen
Mount, J. Russell
Sullivan, Mortimer J.
Wood, Jeffie J.
Veghte, Richard
Van Tuyl, Francis M.

Grand Junction
Farmar, George E.
Hildebrand, Robert A.
Ruhe, Karl
Siapno, William D.
Wolfers, Harvey P.

Greeley
Sears, R. Douglas

Leadville
Lane, Charles E.

Rangely
Barrett, Lawrence Earl
Harpke, Carl Frederick
Kunzman, William Joseph
Mueller, Joseph F.
Rooks, Herbert C.

Sterling
Hansen, Harold D.
Hiestand, F. I.
Rader, L. Glenn, Jr.
Reggin, Walter A.

CONNECTICUT

Bridgeport
Sohon, Julian A.

Darien
McCurdy, Richard C.

Greens Farms
Zavoico, Basil B.

Greenwich
Lovejoy, Donald W.
Townsend, Rex

New Canaan
Roosevelt, Ralph M.

Ridgefield
Boissonnas, Eric
Legrand, Jean C.
Watson, Martin C.

Stamford
Haskell, R. M.

Westport
Mackenzie, K. G.

DELAWARE

Wilmington
Gillson, Joseph L.
Sanders, Marshall Thomas
Wise, Leonard G.

DISTRICT OF COLUMBIA

Washington
Anderson, Carl C.
Cattell, Roscoe A.
Chapman, A. H.
Cheek, Rex E.
Corgan, Joseph A.
Cox, W. Philip
Dante, John H.
Hardison, E. D.
Heilborn, George
Hoffer, Clarence W.
Hoover, Herbert, Jr.
Hopkins, George R.
Jameson, Minor S., Jr.
Kennedy, Harold S.
Laudermilk, Jack I.
Leas, A. Robert
Lindsly, Ben E.
Mackay, D. K.
Manger, G. Edward
McGhee, George C.
Miller, Robert B.
Moore, C. L.
Poulin, John A.
Shinkle, Vincent G.
Smart, Ornan B.
Smiley, John B.
Spratt, Robert E.
Stewart, Hugh A.
Thurrell, Robert F., Jr.
White, Tell T.
Whitney, Paul B.
Wrather, William Embry
Wright, Lundy R., Jr.
Young, Donald B.

FLORIDA

Clearwater
Hayward, J. T.

Cocoa
Brantly, J. E.

Coral Gables
Chapman, I. Thomas
Haider, M. L.
Lambright, Paul W.
Wheeler, O. C.

Fort Myers
Campbell, Robert B.

Jacksonville
Biddison, P. McD.

Lakeland
Clarke, Charles M.
Lyon, Emmett J.

Miami
Hopkins, Oliver B.

Miami Shores
Shields, James C., II

Pensacola
Hamilton, Walter F.
Kujawski, Theodore D.

St. Petersburg
Wiggins, Ralph R.

Tallahassee
Winter, Claud Victor

Vero Beach
Walton, Joseph W.

Warrington
O'Toole, Arthur L., Jr.

GEORGIA

Albany
Graham, Gordon M.

Camp Gordon
Barton, Richard A.

Elberton
Coggins, Burton F., Jr.

Savannah
Coats, Simon F., Jr.

ILLINOIS

Altamont
Robbins, William L.

Belleville
Markwardt, E. W.

Bridgeport
Maude, Joseph V.
Surkalo, Harry

Carmi
Dailey, John L., Jr.
Emery, Donald V.
Fullop, Paul
Harmon, Bill G.
Holz, W. L.
Keyes, William O.
Link, George H.
Vallette, Julian L.

Centralia
Frey, Alfred P.
Gear, Raymond J.
Luckhardt, P. G.
Martin, Paul J.
Payne, Reed W.
Slider, H. C.
Sublett, James D.
Temple, Carl R.
Walker, Bobbie P.
Walker, Keith M.

Chanute
Le Blanc, Robert F.

Chicago
Ball, Clayton Garrett
Baumgardner, H. S.
Bogess, Billy M.
Covell, K. A.
Ferm, Eric W.
Gehring, Wilbur H.
Glos, Edmond A., II
Green, T. Howard
Hoff, H. J.
Johnson, Hjalmar W.
Kelly, Raymond B., Sr.
Liddle, Ralph Alexander
Magrath, Charles B.
Mandell, S. P.
McIlvain, R. W., Jr.
Mygdal, Karl A.
Paul, M. J.
Prior, F. O.
Roe, Walter B.
Sibley, Milton W.
Swearingen, John E., Jr.
Wasson, Theron
Weir, Paul

Crossville
Jones, Charles C., Jr.
Piland, Glen A.

Crystal Lake
Bond, Donald C.

Danville
Green, Lowell O.

Des Plaines
Egloff, Gustav

Downers Grove
Martin, Paschcal

East St. Louis
Dabbous, Anton

Eldorado
Desloge, Joseph

Evanston
Krumbein, W. C.
Reed, Kenneth E.

Flora
Harcourt, G. K.
Lotspeich, William L., Jr.
Williams, James Ronald, Jr.

Glencoe
Young, William P., Jr.

Lawrenceville
Armstrong, George C.

Mattoon
Bottler, Joseph S., Jr.
Eiting, W. F., Jr.
Hammond, Ralph E.

McLeansboro
Kone, Franklin Warren

Mt. Carmel
Davies, David C.
Mintz, John M.
Sharp, C. Sheldon

Mt. Vernon
Brehm, C. E.
Farrar, Fletcher F.
Marvin, Guard S.
McEfee, Reene I.
Moon, Daniel M.
Rue, Edward Evans
Swanbeck, Leonard
Thompson, James W.
Wilson, Bruce L.

Noble
Davies, Nathan C.

Northbrook
Ogden, Walter H.

Olney
Dorland, James T.
Furber, Frederick D.
Jones, Frank T.

Park Ridge
Uhl, Arthur E.

Pontiac
Trainor, Richard

Robinson
Bulla, Robert
Davison, Kenneth
Davison, W. H.
Douville, Gordon A.
Giroux, Guy E.
Haywood, Conrad J., Jr.
Robb, Graham R.
Shick, Robert L.
Stumhoffer, Clarence W.

Salem
Davis, Earl J.
Gardner, Reynolds M., Jr.
George, Jerry Vance
Hockman, James N.
Johnson, Ed. B.
McCarty, J. A.
Monzingo, Arthur J.

Springfield
Williamson, Rayburn
Swanbeck, Leonard

Urbana
Bell, Alfred, H.
De Wolf, Frank W.
Frye, John C.
Witherspoon, Paul A., Jr.
Wuerker, Rudolph G.

Wheaton
Gilbert, Bruce W.

INDIANA

Bloomington
Larson, Richard W.

East Chicago
Matthews, W. H.

Evansville
Atkinson, Jerrel R.
Bradel, George P.
Buthod, John L.
Carman, Charles W.
Davis, Richard C.
Dozier, George E.
Egan, Thomas M.
Fox, Arthur D.
Gallagher, Victor R.
Hamman, Cecil A.
Lavens, John R., Jr.
Lobree, Hal S.
Markey, John A.
Nowlan, Harry H.
Penrod, J. M.
Randall, Duane C.
Rehn, Edgar E.
Reid, Thompson
Rickman, John R.
Sullivan, Robert J.
Vaughan, Jerry R.
Vincent, Ray R.
Wilson, Edward Norman

Fort Wayne
Stone, S. A.

Gary
Ludwig, Norman C.

Griffin
Olson, Dale C.
Tarr, Charles M.

Notre Dame
Peretti, Ettore A.

Terre Haute
Anderson, James D.
Jones, Robert G.
Powell, L. C.
Smithyman, John Edward
Stewart, William Clyde

KANSAS

Augusta
Adamson, Emmett G.

Caldwell
Thompson, F. L.

Chanute
Bowler, Eugene P.
Pate, Carl L.

Chase
Ammann, Charles B.
Collins, O. C., Jr.
Kenner, Robert J.
Taylor, Marlin R.

Coffeyville
Rush, Dan H.

Ellinwood
Albers, Rollin M.
Boone, K. J.
Bristow, Samuel B.
Meyers, Jean Warren
Tiemeier, Paul A.
Walters, Lloyd H., Jr.

El Dorado
Doughty, Tom C.

Eureka
Elliott, William H., Jr.
McGinnis, Ward A.
McPhail, William H.
Miller, Gordon E.
Whittaker, Clive Chas., Jr.

Ft. Riley
Simpson, Donald C.

Garden City
Brown, Maurice L.
Lange, Robert W.

Girard
Blair, John H.

Great Bend
Anderson, Ted C., Jr.
Appelbaum, Lawrence T.
Brown, Dexter H.
Davis, T. C.
Douglass, Jack L.
Fellows, Ray, Jr.
Gallivan, John C.
Kangers, A. J.
Miller, Mac W.
Moore, Charles R.
Myers, L. B.
Nichols, James R.
Parks, Robert W.
Pugh, Thomas D., Jr.
Rockhold, James W.
Saye, Ed, III
Shivel, Paul B.
Steele, James B., Jr.
West, S. R.
White, A. O.

Hays
Klein, Marvin L.

Hoisington
Wilhelm, Julius H.

Hugoton
Atchley, George W.
Flood, William H., Jr.
Pyeatte, C. P.

Independence
Boltacz, John T.
Layton, Dale E.
Lee, Thomas W.

Iola
Bowlus, Thomas H.

Lawrence
Clarke, Gene Francis
Delap, B. J.
Everett, John P.
Folck, Richard Leo
Kurata, Fred
Stephenson, Eugene A.
Stevenson, E. K.
Weinaug, Charles F.

Liberal
Curry, James K.
Dixon, Richard C.
Ford, John D.
Godfrey, G. W.
Goodwin, Leslie E.
Horton, William Leonardo
Howes, Wallace A., Jr.
Jones, John Austin
King, William R.
McDaniel, Robert E.
Phillipe, Jack P.
Pyburn, Thomas D.
Relph, James L.
Riggins, William H.
Ritchie, R. C.
Smitherman, Merion E.

Lyons
Kliewer, Max E.
Queen, John A.
Yarsa, Alex M.

Neosho Falls
Svoboda, Floyd J.

Oil Hill
Vachal, Barney M.

Pratt
Evers, R. B.
Gibbs, James B.

Russell
Ford, W. D.
Jack, Robert S.
Lane, B. B.
Sargent, William M., Jr.

Sedan
Oglesbee, Dwight

Sterling
Arbuckle, Walter K.

Thayer
Allen, Don Dell

Thrall
Hull, Winifield S.
Krehbiel, Dennis L.
Spell, Thomas R., Jr.

Topeka
Trax, David L.

Ulysses
Bennett, Eugene N.

Wichita
Aitken, R. R.
Amstutz, P. T., Jr.
Aukerman, R. A.
Berry, O. H., Jr.
Bostick, E. R.
Brooks, Benton S., Jr.
Brown, Charles S.
Brown, William F.
Calhoun, George H.
Chappell, L. G.
Davis, Horace Chesterfield
Chombart, Louis G.
Collins, A. E.
Curtright, Lawrence C., Jr.
Forsythe, Russell L.
Frick, James W.
Gary, John T.
Hanson, Maurice E.
Harwood, W. K.
Heiser, Frederick W.
Hodgson, Robert N.
Hofmann, Hermann A.
Kennalley, John, Jr.
Loeffler, Richard J.
MacDonald, Gordon C.
Mallonee, Floyd W.
Martin, V. Dale
Maxwell, Eugene L.
Miller, Charles R.
Mingee, James C.
Musgrove, Pierce C.
Parriott, Robert B.
Patrick, Roy E.
Paul, James R.
Puckett, J. R.
Redman, Kenneth G.
Rodd, Charles C.
Ross, John B.
Sholtus, Daniel H.
Smith, Lamont E.
Terry, Lyman
Todd, Carl
Warren, Wyman M.
Westbrook, S. S. S.
Wilkonson, Lester
Williams, Charles C.
Wilson, John H.
Yates, G. L.
Yee, Bing Quai

KENTUCKY

Ashland
Lang, W. E.
Mefford, Nace F., Jr.

Henderson
Arrington, W. H., Jr.

Lexington
Hardwick, Jack
Thompson, Lawrence S.

Louisville
Chammas, Edmond D.
Dunbar, Clarence P.

Owensboro
Beuk, Vladimir
Ellis, Fred M.
Temple, Horace L.

Paintsville
Sherman, Carl W.

Pikeville
Batten, O. S.

LOUISIANA

Abbeville
Murchison, George T.

Alexandria A.F.B.
Johnson, Charles T.

Barataria
Tankersley, William R.

Baton Rouge
Alexander, Granison T., Jr.
Austin, Carl E.
Barbier, Donald J.
Batchelor, James P.
Belello, Joseph
Blackwell, Wm. G.
Chisholm, Pat T. W.
Craft, Benjamin Cole
Craft, Benjamin Cole, Jr.
Gabriel, John L.
Hawkins, Murray F.
Hortman, Ernest C.
Huner, J., Jr.
Jines, James J., Jr.
Koenig, George G.
Langford, John Charles
Loupe, Albin J., Jr.
Muncey, Fred Allen, Jr.
Soule', Levin C., Jr.
Stevenson, W. M.
Vice, William B., Jr.

Bossier City
Bailey, Lee C., Jr.
Cook, John G.
Marion, J. D.

Breaux Bridge
Brown, Traves M.

Bunkie
Thomas, L. E.

Buras
Denton, Thomas L.

Calmette
Amos, Lloyd A.

Cameron
Moseley, Charles V.

Chalmette
Martin, Henry W.

Cotton Valley
McGinnis, Thomas L.

Crowley
Crook, Walter J., Jr.
Wolfe, Donald E.

Cut Off
Fisher, Don Y.
Sheffield, Miller
Stone, Virgil D.

Delhi
Fehrmann, Robert L.
Garnett, Gene N.
Laue, Lamont

De Ridder
Ford, Clyde D.
Ponville, Minos J.

Easton
Cheatham, Frank M.
Griffing, John W.

Erath
Papp, John C.
Reynolds, Gene R.

Eunice
Sylvester, Burke

Franklin
Kaefer, Gene J.
Miller, John C., Jr.

Glenmora
Catlett, R. J.

Grand Chenier
Watkins, Owen M., Jr.

Golden Meadow
Dupree, Harry
O'Shields, Richard L.
Stear, David S.

Grand Isle
Garner, Alva C., Jr.
Homer, Joseph F.
Hubbard, C. B.
Lucy, Marius J.

Gretna
Decker, George J.

Hackberry
Darnell, Grant S.

Harvey
Beach, W. D.
Blomquist, Harry L., Jr.
Butterworth, W. J.
Cain, Jack L.
Combes, John D.
Crews, Robert Nelson
Durall, Dean D.
Ferguson, A. D., Jr.
Fitzpatrick, Harvey J.
Graves, Charles L.
Lott, Clyde
McCabe, John A.
Peterson, A. Fred, Jr.
Price, Edward O., Jr.
Ramseur, Weldon W.
Scott, Hugh L.
Sirgo, Manuel A., Jr.
Smith, Francis H.
Tillman, C. L., III
Wilson, Lawrence M.

Hauma
Cook, Audrey M.
Ebner, Keith J.
Haynes, James O.
Nicholls, Thomas Church, III
Phillips, W. B.
Rome, G. F.
Smith, D. F.
Thomas, Dillard R.

Iowa
Snoddy, William G.

Jena
Moses, W. S.

Krotz Springs
Carmichael, Charles J., Jr.

Lafayette
Bennett, Sam P.
Cabaniss, Bert A.
Cobb, Joseph B.
Cornell, Drew
Crews, James F.
Eckert, Frank E., Jr.
Everett, Robert H.
Gerwick, Fred W.
Hendrick, John O., Jr.
Henry, Charles R.
McKnight, Jerry A.
Montgomery, Paul
Northern, T. P.
Rebold, John H.
Records, Louis R.
Sligh, James Wilmont
Snouffer, William Kirk
Ward, William H.
Yount, Byrd T., Jr.

Lake Charles
Dahl, Arnold C.
Des Jardins, Peter E.
Farley, William Richard
Gaye, Frederick L.
Goode, Oscar N.
Hutto, O. D.
Lindley, K.
Miller, Martin
Moore, James A.
Morgan, Oscar Paul, Jr.
White, Alvin V.

Lockport
Adams, Wayne D.
Decker, R. M.

Mamou
Beaver, M. H.

Maplewood
Helton, William D.

Minden
Moreland, Leonard G., Jr.
Wilson, Sam A.

Monroe
Ambrose, Zuell C.
Augsburger, Clarence H.
Brown, Kermit E.
Coon, Arnold
Riley, Max L.

Morgan City
Colvin, George H.
Fitzpatrick, J. C.
Griffith, Theophilus
Larance, A. L.
Wilson, Fred

New Iberia
Grimmer, George G.
Hebert, Francis F.
Pollard, Charles H.

New Orleans
Acomb, Allen D.
Armstrong, Louis P.
Ashby, William H., Jr.
Atwater, Gordon I.
Aucoin, Riley A.
Aulick, B. W.
Bailey, John F.
Bartlett, Z. W.
Becker, Theodore H.
Blomberg, C. R.
Boldrick, John S.
Bostwick, Douglas L.
Brady, Robert H.
Braunstein, Jules
Bredeson, D. H.
Capps, Charles A.
Cassingham, Robert Warren
Claudet, A. P.
Clayton, M. L.
Clift, William D.
Crowell, Alec M.
Dausch, George, Jr.
De La Barre, F. D. V.
Doh, C.
Donaldson, Robert W.
Dunn, E. A.
Dykstra, Bouwe
Eckart, Robert R., Jr.
Eggleston, Alan F.
Fisher, Leo L.
Flood, T. B.
Ford, Billie W.
Fort, E. W.
Francis, B. L.
Gaffron, John M. C.
Gilkeson, M.
Glenn, Alfred Hill
Grant, Ralph G.
Haley, Lee R.
Harrigan, Gordon E.
Haymon, Elmer D.
Helm, Malcolm B.
Hiser, W. F.
Ilfrey, W. T.
Jay, Webb
Kammler, Albert H.
Kearfott, Carl
Kelly, J. D.
Khoury, George A., Jr.
Kipp, Earl M.
Kucel, Richard J.
Laflin, W. L.
Landers, A. F.
Langford, Stuart S.
Langhetee, Edmond J., Jr.
Langston, James Volney
Le Blanc, Owen
Lee, Clarence O.
Leemann, E. H.
Leon, Leonard
Liston, P. A.
Little, Sterling E.
Lund, Wesley R.
MacDonald, Malcolm W.
Maricelli, J. J.
Mashburn, Clifford H.
McClure, Perry S.
McMillen, George C.
McMurry, Charles R.
McReynolds, Preston S.
McWherter, C. C.
Metzger, John J., Jr.
Mitchell, Donald P.
Moody, William H.
Morel, Ambrose F.
Noll, Paul D.
Oakes, Ramsey L.
Olivier, Fulton J.
Oudt, Fredrik W.
Pearson, Thomas L.
Perry, Dorsey R., Jr.
Peterson, Harluf G.
Posgate, James C.
Power, Charles L., Jr.
Ratliff, J. Paul, Jr.
Ritch, H. B.
Rorison, J. A., Jr.
Sallee, Warren L.
Sampson, C. M.
Schratwieser, John Curtin
Scott, Paul T.
Shirer, Joseph Albert
Simmons, Fred E., Jr.
Smith, Boyd J.
Smith, Joseph W.
Smith, Robert L.
Standley, Milton H.
Sullins, Roy S.
Telford, Billy H.
Terrell, T. H.
Tillotson, T. Carrol
Utterback, Donald D.
Van Burkleo, Glenn G.
Van Duzee, E. N.
Vitter, A. L., Jr.
Wait, Harold V.
Ward, C. J.
Weiner, Charles G.
Williams, James A., Jr.
Winham, Harold Frank
Winn, W. E.
Wise, Don T.
Yeager, John G.
Young, Alberta M.

Opelousas
Chambers, Kinder M.

Paradis
Hoffman, Henry, Jr.

Pointe A La Hache
Schulte, Francis L.
Zimmerman, Robert M.

Port Sulphur
Price, K. T.
Wornat, Richard O.

Raceland
Melancon, Ralph

Rodessa
Ray, Jack H.

Ruston
Corrigan, Glen Lee
Schlemmer, Alfred E.

Shreveport
Abendroth, Gus F.
Adams, Fred B.
Akins, D. W., Jr.
Allen, G. E.
Babin, C. L.
Baker, Glenn J.
Bean, Ernest F., Jr.
Belchic, George, Jr.
Berwald, William B.
Boling, Don R.
Brammer, L. R., Jr.
Burak, Frank, Jr.
Burns, Ben M.
Caster, Ermil Leslie
Clinkenbeard, Paul S.
Coffield, J. M.
Cordell, James C.
Couch, Gwinnett M., Jr.
Crawford, A. H.
Dalton, W. F.
Dorrough, J. Roy
Doyle, E. S.
Durr, Sebastian J., Jr.
Eaves, Everett
Eyre, William P.
Fenwick, Dick T.
Forgotson, James M., Jr.
Fritz, Duane J.
Gallagher, Robert W.
Gariepy, Glen B.
Garrett, R. O.
Gee, C. H.
Golding, Bert H.
Grage, Victor P.
Graham, William B.
Harding, Richard W.
Harlan, Fred E., Jr.
Hendryx, John W.
Jeffers, Marshall A.
Johnson, Theodore William
Kemp, W. M.
Kirkpatrick, H. L.
Kiser, John W.
Kuykendall, W. S.
Lacy, Lloyd R.
Langston, William W.
Lash, Wayne E.
Leisk, James C.
Liscum, Frank N.
Luby, Michael A.
MacRoberts, D. T.
McCann, Wayne L.
McDonough, James D.
McDowell, Robert E.
McGoldrick, Kenneth M.
McLeod, Richard R.
Meltzer, Lee Hillard
Miller, Darrell P.
Morriss, Herbert A., Jr.
Muirhead, D. A.
Nowery, B. M., Jr.
Ogier, Edwin P.
Olson, Charles Robert
Organick, Elliott I.
Patterson, Benjamin F., Jr.
Qvistgaard-Peterson, M.
Popovich, Michael J.
Ragsdale, John G.
Rogers, Robert E.
Ross, Jesse J., Jr.
Roy, R. A.
Scott, Thomas A.
Scott, William C.
Smith, Duncan M., Jr.
Snyder, Millard P.
Spears, Walter H.
Stanton, W. L.
Thomas, Wyatt H.
Valerius, C. N.
Van Hook, Wendell A.
Vowel, Walter Ray
Wade, R. T.
Walker, Jordan A.
Warren, Anne
White, J. L.
Wilson, W. G.
Weyland, Alvin H.

Triumph
Conroy, John Patrick

Venice
Broom, John C.
Guinn, David C.
Hendrick, Henry L., Jr.
Krysuik, Eugene T.
Lemons, Curtis H.
Moorman, James B., Jr.
Pittman, Elmer M., Jr.
Schmit, Horace G.

Waterproof
Goudeau, Willie A.
Phillips, Jack L.

Weeks
Moore, John P.

Westwego
Elderkin, L. W.
Eyler, Albert T., Jr.
Jungschleger, John G.

MARYLAND

Army Chemical Center
Blendermann, Gene R.

Baltimore
Hart, Eugene
Overbeck, R. M.
Singewald, Joseph T., Jr.

Chevy Chase
Richards, Ralph W.

Silver Spring
Blake, Robert W., Jr.

Washington Grove
Rolfe, Walter H.

MASSACHUETTS

Boston
Bowditch, Richard L.
Coburn, William H.
Hiam, Edwin W.
La Croix, Morris F.
Rice, Charles G.
Rice, Neil W.

Cambridge
Haynes, Winthrop P.
Lewis, Warren K.
Mather, Kirtley F.
Mencher, Ely
Michaels, Alan S.

East Walpole
Conrad, Charles T.

Lenox
Stokes, William E. D., Jr.

Watertown
Joffe, Gerardo
Martin, James L.

Westover A.F.B.
Moore, John E.

MICHIGAN

Ann Arbor
Katz, Donald L.
Landes, Kenneth K.
Williams, George Brymer

Clare
Wicklund, John V., Jr.

Crystal Falls
Royce, Josiah

Detroit
Klapka, K. J.
Morrow, Thomas B.
Thomson, R. F.

Grand Rapids
Brady, John R.
Davis, Stanton H., Jr.
Elenbaas, Jack R.
Vary, John A.
Withrow, Harold J.

Houghton
Brown, Norman James
Erickson, Lee

Iron Mountain
Newton, George C.

Jackson
Berry, C. E.
Simpson, John B.

Kalamazoo
Anderson, Charles Stanley

Lansing
Hautau, Gordon H.

Ludington
Paul, Thomas R.

Midland
Cardwell, Paul H.
Gann, John A.
Reed, Charles F.

Mt. Pleasant
Austin, Merton E.
Crate, James A.
Ellison, Raymond H.
Wright, H. H.

Muskegon
Ludwig, George E.

Ishpeming
Boyum, Burton H.

Reed City
Brannigan, James H.
Pinner, Felton Robert, Jr.

Roscommon
Burgess, David Miller, Jr.
Joy, Marshall R.

Saginaw
Agricola, Karl A.
Clark, Charles K.

MINNESOTA

Duluth
Adams, Malcolm M.
Salsich, Le Roy
Spurbeck, George B.

Minneapolis
Armstrong, Lee C.
Bennett, James G.
Davidson, Donald M.
Einhorn, Robert B.
Gwynn, Thomas A.
Huzzey, Thomas E.
Keeler, Clifton M.
Schroth, Harry A.
Smith, Cecil W.
Wade, Henry H.

St. Paul
Johnson, James R.

MISSISSIPPI

Baxterville
Rodgers, John A.
Stone, Glyn
Tsimortos, Paul

Brookhaven
Barthelemy, J. E., Jr.
Eubank, Raymond H.
Gautreaux, E. P.
Justus, J. B.
Lamb, Leslie L.
McGlamery, Robert G.
Rodriguez, Raymond J.

Crosby
Wallace, Bennie H.

Gulfport
Haas, Robert John

Hattiesburg
Boyd, Ellis R., Jr.
England, Ariett C., Jr.
King, C. L.
Mather, Victor T., Jr.
Stiba, Benjamin Franklin

Heidelberg
De Bord, G. E.
Otts, J. M., Jr.

Jackson
Cashion, M. Lyle
Harrell, David C.
Knobloch, Guy J.
Mather, Bryant
Wright, John K., Jr.

Laurel
Ashley, W. H.
Callaway, James
Carlton, James E., Jr.
Caskey, David M.
Dennis, Clyde B.
Druce, Arthur J., Jr.
Etheridge, G. L.
Fox, Raymond D.
Grady, Edward J.
Ham, H. H., Jr.
Hartsell, William H.
Inks, Floyd B.
Keyes, Lawdes Lester
Lane, Herschel E.
Leeton, Harold B.
Lilly, Wilbur R.
McGlothlin, Tom
Oliver, Richard D.
Perkins, H. J.
Petrofsky, John F.
Stanley, J. H.

Maxie
Corbell, Harold C.

McComb
Martin, Edward Hardy

Natchez
Bowers, Daniel E.
Bush, Charles C.
Davis, Jerry Bert
Davis, Leon A.
France, Robert E.
Gauthier, A. C., Jr.
Gore, William P.
James, John C.
Kendrick, Francis E.
McEver, B. J.
Pedersen, Jan N.
Ray, John W., Jr.
Russell, Jim B., III
Sanderson, Wilson I.
Smith, Andrew L.
Underriner, C. F., Jr.
Wyble, Ollie L.

Tylertown
Smith, R. Giffen

Vicksburg
Rushing, Sandy S., Jr.

Washington
Hurdle, J. M.
Johnson, A. R.
Meltzer, Bernard D.
Newsome, J. R.
Pinson, James M.
Rushing, Hollie H.

Waynesboro
Wilson, Henry M., Jr.

MISSOURI

Bonne Terre
Grigsby, G. G.

Columbia
Fraunfelter, George H.
Keller, Walter D.

Ft. Leonard Wood
McClaren, Samuel L.

Joplin
Austin, Arthur B.
Fowler George M.
White, Harold Henry

Kansas City
Hagenbuch, Charles W.
Hall, Albert Le Clair
Hapke, Earle A., Jr.
Hinton, C. H.
Horn, Clifford R.
Jones, Jack R.
Reese, John P.
Riss, R. R.
Riss, R. R., II
Tompkins, W. H.

Rolla
Campen, Fred J., Jr.
Gosen, John W.
Randolph, Earl J.
Roston, J. Paul

St. Louis
Bradley, Richard C., Jr.
Desloge, Bernard F.
Fraser, Alexander
Green, Fred W.
Gross, Henry Emmett
Judge, R. Clarke, III
Macelwane, James B.
Prough, Paul B.
Streett, J. D.
Tolman, Carl

Webster Groves
Averill, John R.
Gudermuth, Chas. A., Jr.
Remment, William E.

Windyville
Jones, Robert Fred

MONTANA

Billings
Allen, Harry E.
Ambler, Harold Leon
Anderson, M. C.
Autry, Mark P.
Boyd, Darrel
Broxson, Lehman Eugene
Buster, John L.
Butterfield, Gale E.
Cowan, John G.
Cox, H. Mack
Darrow, George
Davis, Clyde Russell
Duren, Jack D.
Everett, T. C.
Graham, Roy S.
Hadley, Herbert D.
Holmes, Vernon E.
Hudson, W. T.
Hunkins, Charles F.
Johnson, David E. A.
Lowe, Howard R.
Morris, James I.
Mullen, John T., Jr.
Parker, John M.
Patterson, Harold L.
Schurtz, F. A.
Scott, William Allen
Shay, Daniel Charles
Snyder, Robert D.
Sonnenberg, Frank P.
Sprinkel, Robert L., Jr.
Walthall, W. Frank
Wanner, John J.
Whitr.ker, Earl J.
Wilson, Joseph D.
Yapuncich, John G.

Butte
Amos, David M.
Harnish, Douglas H., Jr.
Harstead, Joseph N.
Hupp, J. E.
Karvinen, Ronald D.
Knutsen, Kenneth Richard

Cut Bank
Armstrong, Richard P.
Bishop, Francis V.

Chinook
Thompson, Charles Lynn

Glendive
Bethel, Franklin Thomas
Davis, Arthur H.
Maki, E. B.
Pederson, John A.
Welbourn, Marshall E.

Great Falls
Chamberlain, Virgil R.

Kalispell
Aronow, Willard B.

Lewiston
Bush, Herbert H.
Thornton, James T.

North Billings
Daugherty, Patrick

Roundup
Elletson, Francis M.

NEBRASKA

Hastings
Schachtler, Dale

Lincoln
Schramm, E. F.

Omaha
Barton, Jackson M.
Bayless, I. N.
Hanley, John M.
Kirby, Maurice E.
Stahl, G. E.

Scottsbluff
Chain, John H.

Sidney
Essley, Philip L., Jr.
Gracey, Joe
Hegwer, John S.
McMillen, Robert E.
Meabon, Harold P.
Sherwood, Clark M.
Smigel, Edmond F.
Zirger, Herschel E.

NEVADA

Ely
Walker, William J.

Kimberly
Hall, Lee

McGill
Kinnear, John C., Jr.

Reno
Gianella, Vincent P.
Skinner, James E.

NEW JERSEY

Alpine
Paige, Sidney

Burlington
Samuels, M. L.

East Orange
Walter, H. P.

Jersey City
Jacobs, Ronald Joseph

Linden
Brown, D. F.

Montclair
Hessel, Frederick A.

Morristown
Estabrook, Edward L.

Murray Hill
Meinert, H. J.

Newark
Grow, George C., Jr.

New Brunswick
Johnson, Helgi
Meditz, Richard D.
Souder, Roy
Scalera, Robert

Paulsboro
Evans, Louis P.
Nelson, T. W.

Plainfield
Buel, H. G.

Princeton
Erdman, C. Pardee, Jr.
Fiske, Richard Sewell

South Plainfield
McLellan, Roy D.

South River
Rohrirsch, Joseph H.

Sparta
Scudder, Ronald Jay

NEW MEXICO

Albuquerque
Charles, Robert C.
Holland, Arthur F.
St. Germain, Arthur A.

Artesia
Gray, Ralph L.

Aztec
Maxwell, Norman E., Jr.

Bayard
Hamilton, Clyde L.

Carlsbad
Acklin, Floyd, Jr.
Blackman, Roy H.
Dibble, Robert D.
Pratt, Wallace E.

Farmington
Budd, Harrell, Jr.
Coel, Edward John
Egan, John A.
Greer, Albert R.
Kreger, Joseph E.
Linton, William J.
Newman, J. M.
Oberly, Edward S., Jr.
Sur, Forest J.
Walsh, Ewell Norwood

Hobbs
Adams, J. W.
Albright, John Douglas
Burgess, Charlie B.
Cabaniss, Rex C.
Canon, Olin B.
Carlton, Riley V.
Chapman, Peter F.
Chestnolvick, John R.
Compton, Troy V.
Conner, Martin C.
Davis, Hubert E.
Evans-Lombe, W. R.
Falcon, Francis
Fischer, Ernest J.
Foster, Vincent D.
Fuller, Luverne B.
Guynn, E. W.
Heins, Robert W.
Holmes, Howard P.
Huddleston, Kenneth R.
Kemnitz, A. A.
Korzekwn, Clement Robert
Kranyak, Attila Dennis
Laflin, George P.
Lane, Robert D.
Locker, George R.
Lukehart, Charles O.
Macqueen, Peter A.
Maddox, J. F.
Maxwell, O. T.
McCague, John M.
McCain, Jerry
McPeters, Kenneth D.
Melton, Marion L.
Midkiff, O. Kenneth
Miller, Paul W., Jr.
Nolan, W. E.
Rice, Douglas W.
Rosenkranz, Ronald
Ryan, J. V., Jr.
Scott, Robert P.
Shackelford, Henry P.
Smith, Mike O., Jr.
Smith, Robert F.
Staley, Glenn
Steinert, Allen R.
Thompson, James Evan
Torgerson, Jeralde L.
Turner, James E.
Wallace, D. S.
Williams, Robert M.
Yoakum, George
Yuronka, John, Jr.

Jal
Bernard, Fred G., Jr.
Cole, Charles M., Jr.
Cummings, Aaron
Haight, Jack N.
Spitler, Marion E.

Las Cruces
Haymes, William G.

Maljamar
Davis, Russell Judy, III
Iverson, Barley Gilbert

Monument
Abbott, Richard H.
Abbott, William G.
Houser, Carl M.

Roswell
Bauer, Roy M., Jr.
Brown, Jack W.
Bunte, Arnold S.
Crandall, Roderic
Eaton, George W., Jr.
Gilbreth, Oma K., Jr.
Hanson, Ernest A.
Kelley, Clarence L.
Kelly, John Martin
McCoy, William G.
McMinn, John Robert
Morrell, Foster
Podpechan, Frank W.
Taylor, Madison I.

Santa Fe
Auten, John D.
Lunt, Lamar
Rhodes, Harlan N.
Wilson, Parker

Santa Rita
Granlund, Walter

Socorro
Taylor, Langdon B.

Tatum
McGinty, Gerald
Richardson, W. N.

White Sands Prov. Ground
Clark, John M.

NEW YORK

Bronx
Appleton, Harry N.
Simon, Sol

Brooklyn
Bradley, Francis T.
Einersen, Charlotte C.

Dobbs Ferry
Sells, Harold R.

Forest Hills
Greenstein, Robert I.

Larchmont
Blue, Sidney D.

New Rochelle
Kirkendall, Ernest O.

New York
Ahalt, Gordon F.
Anttila, John W.
Aries, Robert S.
Bailey, Carroll C.,
Baker, Norval E.
Baker, Raymond F.
Bartlett, F. W.
Baucum, A. W.
Berlin, Edson
Breyer, Frank G.
Briggs, Fred, Jr.
Brokaw, Albert D.
Brown, Chester L.
Brown, Donald M.
Brown, Harry M., Jr.
Brunjes, Henry L.
Burnside, L. N.
Campbell, W. J.
Cantey, William D.
Carter, Calvin B., Jr.
Case, Hadley
Case, W. B.
Clark, James A.
Clark, W. A., Jr.
Clements, George F., Jr.
Coles, Roy D., Jr.
Collins, Joseph P.
Connaughton, Edward M.
Corbett, Clifton S.
Corey, George H.
Cord, Richard H.
Corless, George B.
Cowan, Lester A.
Cram, Edward C.
Crum, Harry E.
Cumming, D. R.
Curtice, A. A.
Damp, Ralph E.
Darrow, Frederick R.
Daveler, Erle V.
Davidson, George A.
Davies, Fred A.
Dawson, E. Robert
Del Giudice, Guy R. M.
Dennis, Richard C.
Dixon, A. Faison
Dobson, E. G.
Dodson, Charles R.
Dohm, Christian F.
Dreyling, Lewis J.
Duce, James Terry
Eagles, Homer M.
Eddins, George E.
Eristoff, Constantine S.
Fath, A. E.
Faulkner, Ross Hilton
Ferguson, Wililam H.
Flagler, C. W.
Freie, A. J.
Fuller, Earl
Galloway, Alan J.
Gibbon, H. A.
Gillespie, Darl D.
Godfrey, Richard
Gorham, E. L., Jr.
Grove, Brandon H.
Hall, James H.
Hammar, Harold D.
Hanners, Albert J.
Haworth, A. John

New York—*Continued*
Hayes, E. P.
Heath, Russell D.
Hedberg, Hollis Dow
Henault, Emil A.
Herold, John S.
Hess, Lorain E.
Hewitt, Ed. T.
Hill, Kenneth E.
Hollis, Raymond W.
Holman, Eugene
Howard, Frank A.
Hulsey, Bob T. H.
Illyefalvi, Phyllis Schwab
Isom, Edward W.
Jablonski, Eugene
Jackson, B. R.
Jacobsen, Lorraine
Johnson, Robert H.
Johnston, Joseph J.
Jones, W. Alton
Kane, Nathan M.
Kaufmann, Godfrey F.
Kennedy, Edwin L.
Kennedy, Ezra J., Jr.
Kinney, Harry D.
Kleckner, William H.
Klimkiewicz, Wade John
Knapp, Thomas J.
Knebel, George Moses
Knutson, C. J.
Kozik, Eugene
Kraft, Philip
Landa, Maynard I.
La Piere, Gilbert H.
Leary, Daniel F.
Lilley, Ernest R.
Liss, V. Mitchell
Livingston, Myran J.
Lockett, Charles L., Jr.
Long, Walter E.
Lovejoy, John M.
Lynch, Rev. J. Joseph, S. J.
MacQuarrie, J. M.
Marshall, Elgin J.
Martin, James W.
Mayhew, Zeb
McAuliffe, Henry E., Jr.
McCulloch, Joseph Paul
McIntosh, Albert J.
McKee, H. Harper
McMillan, Wallace
Merrill, Gregor C.
Meyer, Kenneth E.
Miglietta, J. R.
Miller, Horace P.
Miller, K. T.
Moore, T. V.
Morford, Bud W.
Morton, Byron B.
Moulton, Gail F.
Munoz, J. R.
Murphree, Eger V.
Myers, Le Moyne W.
Neff, Charles H.
Neilson, William, Jr.
Nelson, F. M.
Nix, Dale
Ogden, Clarence B.
Olson, Walter S.
Paez, Jose G.
Park, David Eugene
Payne, John, Jr.
Penn, Sheldon H.
Perebinossoff, A. A.
Phillips, F. G.
Pogue, Joseph E.
Poor, William B.
Racek, Edward W.
Railing, Lewis L., Jr.
Read, Norman H.
Reed, C. B.
Rees, E. M.
Reiss, Royal W.
Reynolds, Jordan K.
Rice, C. Leslie, Jr.
Rieber, T.
Rising, Albert E., Jr.
Ristori, John W.
Robie, Edward H.
Ruedemann, Paul
Rynalski, A. T.
Salnikov, Ivan S.
Schider, Rudolphe
Schwarz, Robert L.
Sealey, Fred C.
Siegel, Robert
Sladic, Matthew J.
Snyder, Richard W.
Sowerwine, E. O.
Speaker, William H.
Stark, Mitchell
Stephens, Claude O.
Strelsin, Alfred A.
Tapp, T. L.
Terry, Lyon F.
Thomas, Byron K.
Thompson, Chaunce, Jr.
Toone, L. A.
Van Der Linden, B. H.
Van Dongen, Leonard Charles
Van Paasschen, J.
Walker, N. Morgan
Walker, R. Gordon
Walsh, Thomas E.

Walter, Louis
Wardlaw, Harold W. R.
Warren, John Edwin
Waszkowski, Henry, Jr.
Watson, B. S.
Watts, Albert E.
Weber, George H.
Weeks, L. G.
Wells, O. W.
Westling, R. E.
Whetsel, Raymond V.
White, Foster Lee
Wilcoxson, Leslie S.
Wilhelm, O.
Wise, M. Smith, Jr.
Wise, Richard A.
Witherspoon, Gavin
Woessner, Claude
Zwick, Ben F.

Olean
Laverty, F. W.

Scarborough
Shannon, Philip F.

Searsdale
Gibson, Lloyd C.

Schenectady
Suits, C. G.
Wirene, W. A.

Syracuse
Apfel, Earl T.

Troy
Beers, Roland F.

Wellsville
Holbrook, George W.
Thornton, Knight

Yonkers
Moyd, Pauline

NORTH CAROLINA

Durham
Berry, Willard

NORTH DAKOTA

Dickinson
McCormick, John J.
Towse, Donald F.

Grand Forks
Meldrum, Alan H.

Stanley
Strobeck, Aldon

Tioga
McBryde, Oliver C., Jr.

Tioga
McBryde, Oliver C., Jr.

Williston
Aalseth, Earl P.
Dallas, Dois D.
French, Lewis L.
Montgomery, Melvin M.
Nedom, H. Arthur
Reithmiller, Donald
Sinex, Bradford J.
Timm, Helmuth
Webb, Gareld O.

NEW HAMPSHIRE

Durham
Lovell, Alden Louis

OHIO

Canton
Belden, M. B.
Bergh, A. Lindsey

Cincinnati
La More, Francis E.
Leverett, Miles C.

Cleveland
Brown, Carl P.
Farrand, William H.
Robinson, J. French

Columbus
Andrix, Ned W.
O'Rourke, Edward V.
Buchanan, D. W.
Cashell, Jack
Cockfield, James E.
Ertl, Teil
Fischer, Roland C.
Kendrick, John F.
Ring, Dewitt T.
Russell, H. W.
Scutt, Harry L.
Todd, F. C.
Vockel, Richard L.
Williams, Clyde
Wyer, Samuel S.

Dayton
Cornell, David

Euclid
Williams, Thomas B.

Fairborn
Dickey, Leonard C.

Findlay
Askam, John C.
Barlow, William H.
Bish, Glenn F.
Clark, Glynn A.
Dumbros, Nicholas G.
Emery, Wilson Barton
Funk, Fred J.
Noble, Gilbert W.
Poe, G. F.
Snyder, William O.
Ward, E. Paul
Yost, W. Jacque

Jackson
Jones, Edwin A.

Lancaster
Alten, George H.

Lima
MacDonell, James Alfred

Newark
Cochran, Patrick F.

Shaker Heights
Vactor, Howard

St. Clairsville
Balcar, Frank

Zanesville
Straker, John W.

OKLAHOMA

Ada
Simpson, Joe W.

Ardmore
Allen, Roy W.
Bashe, Robert W.
Butler, Roy
Degeer, W. Don, Jr.
Fell, Harold B.
Landrum, W. E. Pete
Leonard, James E.
Neustadt, Allan
Rummell, W. B.
Shortridge, Charles G.
Spencer, L. B.
Stokes, Dana D.
Sutherland, W. C., Jr.
Tomlinson, C. W.

Bartlesville
Bailey, Daniel F.
Beach, Charles L.
Beecher, Charles E.
Belknap, William B.
Bertch, Thomas M.
Berthelot, B. W.
Binckley, Charles W.
Burman, Lawrence M.
Carpenter, Paul G.
Casler, Earle T., Jr.
Chin, Tim
Clinton, George W.
Cook, Alton B.
Corliss, Earl R.
Crawford, F. W.
Davidson, Charles David
Dean, Maurice R.
Dolman, Jack A.
Dorris, Paul J.
Edinger, Donald B.
Eilerts, C. Kenneth
Fisher, Henry B.
Fowler, Harry C.
Grandone, Peter
Greene, Freddie M.
Halderson, M. H.
Hall, Alvin E.
Hall, Merle L., Jr.
Hannum, George H.
Hatfield, J. R.
Hendrickson, Gordon E.
Herman, Alois T.
Heston, J. Ed.
Hudson, T. B.
Johnston, Kenneth H.
Kaufman, Milford J.
Kelly, Harold S.
Krutsinger, Virgil W.
Lovering, Franklin F.
McCready, William S.
McGhee, V. T.
McKeithan, D. R.
Miller, John S.
Modrall, J. W.
Poettmann, Fred H.
Popovec, George
Powell, John P.
Price, Harold C.
Riggs, Calvin H.
Rippel, A. M.
Smith, R. Vincent
Smith, Shofner
Taliaferro, D. B.
Tarner, Jack
Thawley, Leonard H.
Turner, C. Ed.
Turner, Marshall C.
Walden, Billie W.
Walker, C. J.
Walls, Wililam S.
Washburn, Edward N.
Weeks, Warren B.
Welchon, James K.
Wood, Gilbert, Jr.

Bristow
Bull, Kenneth W.

Cement
Boothe, William A.
Knapp, Harold H.

Chelsea
Milam, Hinman Stuart

Chickasha
Cox, Byron V., Jr.
Fitzgerald, Daniel E.
Olson, Lawrence C.
Sneed, Jimmy
Spires, H. D.

Cushing
Weinland, Harold Albert

Delaware
Turner, Neil G.

Dewey
Evans, Douglas S.
Watkins, J. Wade

Drumright
Fly, J. Paul
Holden, John C.
Morris, Joseph A.
Petty, Jewell Alton
Marrs, Doyle G.

Duncan
Anderson, Ross E., Jr.
Bradley, B. Jack
Causey, Norman H., Jr.
Christie, W. J.
Clason, C. E.
Curtis, Willard L.
Gras, Ernst H.
Green, Daniel P.
Halliburton, Erle P.
Halliburton, John C.
Hassebroek, Willard E.
Hower, Wayne F.
Kilgore, J. Grover
Klingensmith, Kenneth L.
Lee, Harrison B.
Manson, Charles D., Jr.
Meaders, L. B.
Montgomery, Phil C.
Morrisett, O. L.
Olson, C. C.
Ostroot, G. Warren
Owsley, William D.
Powell, William Kelley
Saunders, Calvin D.
Tapper, Wilfred
Tomlinson, John R.
Underwood, David W.
Waters, A. B.
Wilson, Roger L.
Woods, John W.

Edmond
Liming, Hugh F.
Waterman, Chester B.

Elk City
Camargo, Orlando
Redic, John Gabriel

Enid
Coburn, Richard W.
Cotton, Doyle W.
Laws, James T.
Muir, J. Lawrence
Saner, Walter B.

Fairfax
Knoblock, Richard Neal

Guymon
Kendall, E. Clayton, Jr.

Healdton
Bresenham, J. J., Jr.
Carter, Gene A.
Koederitz, William A.
Mullins, Jesse F.
Shannon, Larry C.
Smith, Paul K., Jr.
Williams, Victor R.

Hooker
Keaton, James C.

Hugo
Caylor, Floyd M.

Kiefer
Bearly, Marion F.

Kingfisher
Schmidt, Robert L.

Lindsay
Murray, Robert P.
Talley, Martin L.

McAlester
Mellor, John F.

Miami
Neal, Charles A., Jr.

Muskogee
Bradley, O. U.

Norman
Branson, Carl C.
Brubaker, M. Wayne
Campbell, J. M.
Carson, W. H.
Chatenever, Alfred
Childers, Dan D.
Cloud, Wilbur F.
Flowers, R. L., Jr.
Hardy, William C.
Hise, Bill R.
Honnold, David E.
Huntington, R. L.
Hvolboll, Victor T.
Indra, M. K.
Laidlow, P. W. A.
McGee, James M.
Melton, Frank A.
Menzie, Donald E.
Nelson, Madison F.
Reid, Laurance S.

Nowata
Capron, Wayne C.
Fiegener, Joseph L.
Hobson, J. C., Jr.
Holbert, Don R.
Hughes, James D.
Johnston, Deryl W.
La Pointe, C. L.
Scott, Garner M.

Okemah
Patton, W. R.

Oklahoma City
Abernathy, Jack H.
Armstrong, Robert A., Jr.
Arrendiell, Robert W.
Asay, Clinton Ted
Atwood, John H.
Baker, Weldon M.
Ball, William W.
Barbour, John W., Jr.
Bauman, Willard E.
Beckmann, Lawrence J.
Beebe, Byron W.
Berryman, James Eddie
Bodemann, Louis C., Jr.
Brauchli, Rud. W.
Brooks, William W.
Bugbee, James M., Jr.
Burns, Robert H.
Camp, Richard W.
Carpenter, Forrest L.
Chapman, Robert B.
Christner, Herbert D.
Cobb, George H.
Congdon, Clyde G.
Coogan, John C.
Cooke, John T.
Corbin, Joseph A.
Crawford, Ronald F.
Criss, Charles R.
Dahlgren, Elmer G.
Dakin, John D.
Daniel, William A.
Denham, Ralph R., Jr.
Diehl, Ray P.
Donohoe, Charles W.
Dooley, David L.
Dowds, John P.
Dreher, Harry P., Jr.
Dunn, Jack W.
Edinger, Ward Munson
Elkins, Lincoln F.
Ernst, Edward A.
Farris, Riley Floyd
Field, Joseph H.
Findeiss, Ted Carl
Fisher, Eugene
Flesher, Cranston Wesley
French Richard W., Jr.
Gassett, Paul L.
Geissler, Paul M.
Gond, Wilmer E.
Gogniat, Stephen
Grady, James E.
Hancock, Ray A.
Hankowsky, John S.
Hathorn, Don H.
Hegglund, Martin O.
Hicks, J. D.
Hill, Freeman L.
Hixon, William L.
Holman, Harvey H.
Huffman, Kenneth P.
Ingram, Charles C., Jr.
Janovy, John
Jones, Tom T.
Kimmell, Garman O.
Kirkman, Claude L.
Korn, Norman
Laughlin, R. W.
Laurence, Lawton L.
Laurence, William Grundy
Lewis, E. F.
Lowe, Robert M.
Loye, P. E.
MacIvor, Roderick K.
Maly, Joe W.
May, J. Thomas
McBride, Lloyd R.
McCormick, Robert L.
McDonald, Pat
McGee, D. A.
McKee, Donovan S.
McLain, M. W.
McMahan, R. C.
Milner, Fred E.
Mosley, William N.
Moss, Rycroft G.
Nation, William R.
Newby, Jerry B.
Nicholson, Edward B.
Noll, C. R., Jr.
Nye, J. Marshall
Ockershauser, Thomas E.
Orman, Freeman L.
Parker, Robert G.
Parks, George B.

Oklahoma City—*Continued*
Pasquella, George
Patty, Duncan V.
Pearson, Walter C.
Pendley, Dee F., Jr.
Phelps, Warren D.
Poppe, Raymond E.
Powell, Herbert E.
Price, Raymond, Jr.
Puzin, L. A.
Ramsey, Jim R.
Riley, Homer G.
Rozelle, F. McQueen
Sabin, Dewey J.
Sandlin, Walker P.
Saunders, G. E.
Scull, B. J.
Sengel, E. W.
Sheets, C. Burton
Shelton, Howard B.
Smith, Frederick J.
Smith, V. L.
Stokey, Ernest W.
Stueve, Winfred H.
Sweeney, Albert E., Jr.
Taylor, Burrell G.
Teddlie, J. E., Jr.
Trimble, Glenn Alan
True, Robert W.
Waag, William R.
Weaver, Bill R.
Whiteley, Burton W.
Willibrand, Frank H.
Wilshusen, Richard C.
Yingling, Edward E.
Young, Elburn E.
Zaremba, Hubart B.
Zimmerman, Grier D.

Okmulgee
Capshaw, John C.
Maples, Steve C., Jr.
Quillin, J. Paul

Pauls Valley
Campbell, Arnold E.
Deem, Doy C.
Freeze, Gerald I.
Gautreaux, Pierre J., Jr.
Harry, Edward E., Jr.
La Londe, Clarence M.
Lindsey, Bill J.

Pawhuska
Barber, R. C.

Ponca City
Alani, Ghalib H.
Arnold, Edwin S.
Burrows, David B.
Cassida, Walter
Coffer, Henry F.
Conley, Francis R.
Cook, Robert E.
Davis, J. Gilbert
Dodd, Charles G.
Felsenthal, Martin
Forbes, Frank H.
Greathouse, W. D.
Guereca, R. A.
Jaworek, W. Gibson
Joers, John C.
Kerr, John F.
Lybarger, David Dean
Manering, Eldridge L.
McGuire, Edward M.
Mead, William A.
Millikin, B. T., Jr.
Reynolds, Jack J.
Rowe, Martin D., Jr.
Spencer, John R.
Waggoner, Bert L.

Purcell
Elsey, George V.
Erbe, Charles B.

Sand Springs
Short, Bill

Seminole
Gross, Angelo C.
Marty, James R.
Rossman, Charles C.
Smith, Paul C., Jr.

Shidler
Austin, Homer D.
Benz, Lewis W.
Blanda, Peter
Haas, Gilbert G.
Harrison, John F.
Holladay, John M., Jr.
Knapp, K. K.

Stillwater
Easton, Clarence W.
Fitch, Ernest C., Jr.
Irons, Homer J.
Nobles, Melvin A.
Pace, Everett L.
Woods, Anson Trent

Tulsa
Acher, Ross M.
Adkisson, J. F., Jr.
Albert, E. R., Jr.
Alexander, Herbert
Alexander, Howard
Amstutz, Ray W.
Andresen, Kurt H.
Andrews, Lewis E.
Arnold, D. Clayton
Atwood, Kenneth L.

Oklahoma City—*Continued*

Ayers, Roscoe G.
Baird, Thomas
Baker, Forrest D.
Baker, Philip D.
Barton, Robert C.
Bartram, John G.
Bass, Clarence C.
Bass, William R.
Bearden, Wm. G.
Becker, Dwight L.
Beesley, Jack H.
Beets, R. W.
Bellamy, Robert B.
Bennett, Arthur D.
Benway, Rex B.
Berg, Harold E.
Bernard, Harold B.
Berning, John A.
Berry, V. J., Jr.
Bickel, Chester A.
Binder, George G., Jr.
Bleakley, William B.
Blenkarn, Kenneth A.
Blevans, Don W.
Blincoe, Edward I.
Bobek, Jack E.
Bolton, H. Ross
Bonifazi, Arthur W.
Borgan, Richard L.
Borden, Guy, Jr.
Born, W. T.
Bossler, David P.
Boucher, F. G.
Bourne, Benjamin W.
Boyle, J. H.
Bradley, Robert I.
Braeutigam, Ray L.
Brainerd, Harold W., Jr.
Brake, E. W.
Brice, John W.
Bridges, Harry B.
Brock, Lawrence E.
Brooks, J. B.
Brown, Charles Arnold
Bruce, William A.
Brundred, L. L.
Buck, John H.
Buck, Willis A.
Buckwalter, Frederick G.
Bullard, Edgar Fitch
Burge, L. L.
Burja, Edward O.
Burke, W. H.
Bush, J. B.
Bussell, Robert Q.
Byers, James E.
Byers, John C.
Bystrom, Gordon Ray
Callaway, Frederick H.
Campbell, James L.
Campbell, John O., Jr.
Campion, Frank E.
Capps, William M.
Card, G. H.
Carr, Raymond M.
Carson, William D.
Caylor, Garth W.
Caywood, Robert M.
Chapman, M. E.
Christie, Robert S.
Chronister, William Carl
Clark, Joseph B., Jr.
Cobbs, James H.
Cole, Joseph Glenn
Collins, H. D.
Collins, William W.
Conboy, Robert L.
Conkling, Robert H.
Cooley, Herbert M.
Corbitt, James P.
Cottrell, G. W.
Craig, Forrest F., Jr.
Crane, John Kenton
Crawford, William J.
Crews, William Daryl
Crisman, Harold L.
Culp, John D.
Dahlman, Clark E.
Danchertsen, Charles H.
Danzer, Richard Harold
Davis, Louis F.
Davis, Sidney H.
Davis, Warren B.
Deck, George William, Jr.
Denison, A. R.
Dereniuk, Harry
Dickey, Parke A.
Dickson, Robert L.
Dille, Glenn S.
Dinger, William C.
Dixon, Philip C.
Doehring, Carl D.
Dulin, Wilford A.
Dunn, George V., Jr.
Dunn, Thomas H.
Earlougher, R. C.
Eckel, John Edward
Elkins, Lloyd E.
Elliston, H. H.
Harry A. Ells, Jr.
Elson, William H., Jr.
English, Homer C.
Erwin, Alan B.
Evans, Robert B., III
Fagg, Leo W.
Fast, Clarence Robert

Oklahoma City—*Continued*

Fearon, R. E.
Finch, Lewis, Jr.
Finklea, Ernest E.
Fitzgerald, P. E.
Folger, Charles J.
Folger, Frank C., Jr.
Ford, C. E.
Ford, William T.
Foster, Jack
Fox, I. William
Francis, A. W., Jr.
Franz, F. Leland
Fulton, Robyn
Gardner, Frank J.
Garlington, R. E., Jr.
Garrick, David A.
Garst, Arthur W.
Gatlin, Carl
Gearhart, Don R.
Geffen, Theodore M.
Ghorayeb, Habib N.
Gibbon, Anthony
Gibbs, L. T.
Giles, Frank S.
Ginter, Roy L.
Gladfelter, Robert E.
Glass, Eugene D.
Glover, Robert C.
Godbold, Aubrey C.
Gove, Norman B.
Grady, Guido O.
Grant, Bruce F.
Gray, Lloyd L.
Gregath, James R.
Grieves, William A.
Griffin, H. T.
Griffith, Glenn R. V.
Groeneman, Austin
Gwinner, R. H.
Haley, Kenneth W.
Hall, Howard N.
Hall, Phillips C.
Hamilton, Robert G.
Hammond, John Payne
Hamner, Francis M.
Hampton, De Atley
Harbison, J. M.
Harder, H. O.
Harding, R. S.
Harris, Thos. P.
Harstine, John H.
Haugh, Wendell J.
Hawkins, Glenn D.
Haynes, G. Wilbur
Healy, J. E.
Heath, Willis A.
Hieger, Dale R.
Hillsman, J. Mathis
Hockaday, Donald E., Jr.
Hocker, Richard L.
Hollinger, George C.
Holsapple, Lawrence W.
Holsapple, Lloyd D.
Hopper, Walter E.
Horner, Victor
Horton, Harry L.
Houy, Carl A.
Howard, Dan O.
Howard, George C.
Hower, Thomas C.
Hudson, Eddie J.
Huebotter, E. E.
Huey, Richard K.
Hughes, Ivor H.
Hulings, N. M., Jr.
Hunt, Elton B., Jr.
Illeman, Daphne Collins
Jacoby, Robert H.
Johnson, Donald R.
Johnson, Douglas O.
Johnson, Jesse P.
Jones, Frank O.
Jones, Kenneth E
Kaveler, H. H.
Kaye, Emby
Kearley, James Herman
Keating, Anthony F.
Keeling, Lee A.
Kellogg, Walter N.
Kendall, W. L.
Kendrick, C. L.
Keplinger, Charles Henry
Kidd, Harold C.
Kiess, Myron C.
Kilgren, Evert W.
Kirschner, Robert D.
Kluck, Fred V.
Knappen, Russell S.
Knotts, Max L.
Koeller, Raymond C.
Kravis, Raymond F.
Kriegel, Monroe W.
Ladd, Herbert W.
Lambert, Joseph G.
Lamberton, William J.
Lamoreaux, William E.
Landis, Bruce A., Jr.
Larkey, Charles S.
La Rue, John W.
Leach, Robert O.
Leas, William J.
Lembcke, Richard E.
Levorsen, A. Irving
Lilystrand, T. O., Jr.
Lindeman, Frank, Jr.
Louy, Frank, Jr.

Oklahoma City—*Continued*

Lubinski, Arthur
Macpherson, L. A.
Maddox, Arthur
Mallinger, Morton A.
Manion, Peter P., Jr.
Manley, Harold W.
Mapes, Clarel B.
Mardock, Edwin S.
Martin, Robert George, Jr.
Maul, Robert V.
Maxey, James R.
May, Russell D.
McCann, Burton E.
McCaslin, Leigh S., Jr.
McCormick, Joseph C.
McGaha, G. W.
McGirl, J. N.
McHugh, Jerome P.
McIntosh, Charles W.
McMahon, William A.
McNally, H. J.
McNatt, Eugene M.
McSpadden, Thomas Willard
Means, James O.
Meers, R. J.
Megill, Robert E.
Melton, Homer Doster, Jr.
Merliss, Frederick E.
Messer, Elmer S.
Miles, Frederick V.
Millard, Frank S.
Millikan, C. V.
Mills, Earnest J.
Mills, W. H.
Minnich, Clark S.
Moore, John I.
Morrow, Sam D., Jr.
Moss, Cleveland O.
Mouser, A. M.
Musgrove, Irvin William
Nabors, Fred L.
Nagy, Bartholomew
Nease, Charley W.
Nelimark, John H.
Nelson, R. A.
Neumann, L. Murray
Nielsen, Emery H.
Ogden, Laurence A.
Oliphant, Charles W.
O'Neill, Vernon L.
Ousterhout, Raymond Sherburn
Owens, Willilams W.
Palmer, William C.
Parker, Wallis P.
Parrish, David R.
Parse, Robert G.
Patrick, Earl F.
Patton, M. S., Jr.
Peabody, Harlan W.
Pelzer, H. L.
Penn, M. Buford
Perry, Robert O.
Petree, E. L.
Phenicie John W.
Phillips, William V.
Pierce, Albert E.
Pirson, Sylvain
Priestman, G. D.
Purdum, Frank
Rae, Colin C.
Rahme, Habib S.
Randall, Billy V.
Raney, Clark
Rapport, L. A.
Reese, Roy W.
Reeve, J. R.
Reisher, Paul H.
Renberg, Kenneth
Reynolds, Karl W.
Rhees, Frank Herbert
Rice, Bruce A.
Riggs, Robert J.
Robinson, J. M.
Rorschach, H. E.
Rowley, Donald M.
Ruddick, Charles K.
Rugg, Fred E.
Rzasa, Michael J.
Sage, John F.
Sanderlin, James L.
Sanderson, Samuel G.
Sarem, Amir M.
Schafer, Herbert E.
Schneider, Frederic Nicholas
Schultz, Paul R.
Scott, P. P., Jr.
Sears, Roy C.
Shanor, Paul J.
Shaw, George R.
Shebaklu, Khalil
Sherman, Henry A.
Sherry, William J.
Shivers, Lonnie G.
Shupp, Danny E.
Sidwell, Carroll V.
Silverman, Daniel
Skeith, Jack T.
Slater, Robert O., Jr.
Smith, Angus Carlyle
Smith, Charles K.
Smith, Donald E.
Smith, Loyd Thompson
Smith, Marion R.

Oklahoma City—*Continued*

Smith, Roy H.
Smith, Tracy E.
Smith, Oziel Lewis, Jr.
Snow, D. R.
Sommer, Robert C.
Sons, Max C.
Southmayd, W. C.
Spurlock, James W.
Stanton, Potter
Staudt, John G.
Steinle, William D.
Stewart, Charles R.
Stewart, Frazier M.
Stiles, William E.
Stinson, James A.
Stirling, Marshall L.
Stolz, Gustav, Jr.
Strand, James A.
Strider, Haynes L.
Strother, G. D.
Swearingen, Wayne E.
Szasz, Stephen E.
Taubman, Louis
Taylor, Albert W.
Taylor, Clarence P.
Teel, James R.
Teis, Kenneth Robert
Terry, Mark L.
Terwilliger, Paul L.
Thomas, Kenneth H.
Thompson, James L.
Timmerman, E. H.
Todd, John C.
Townsend, Phinn W., Jr.
Tracy, George W.
Turner, William J.
Vaughn, Carlos R.
Vaughn, Joseph C.
Vincent, Renic Price
Wagner, Oscar E., Jr.
Walker, A. W.
Walker, Clayton
Walker, Richard E.
Walker, S. Chadwick
Walters, John Dewitt
Wanenmacher, J. M.
Wasicek, Jerry J.
Weatherby, Benjamin B.
Weatherford, Carl L.
Weber, Leonard B.
Welch, L. W., Jr.
Welge, Henry J.
Wells, E. C., Jr.
Wenger, Everett S.
Westby, Gerald H.
Whitmore, W. P.
Wible, James P., Jr.
Wilkins, Robert B.
Williams, Guy F.
Williams, Philip S.
Willson, C. O.
Wilsey, Lawrence Earl
Wilson, Clair C.
Wilson, Connie L.
Wilson, David A.
Wilson, Ralph H.
Wood, Bennie B., Jr.
Wright, F. F.
Wright, Myron A.
Zaba, Joseph
Ziemer, Charles W.

Tyrone
Auld, Donald K.

Velma
Jaber, George

Wewoka
Barb, Glen W.

Wirt
Erskine, Herbert S.

Waleo
Liddell, William W., Jr.

Yale
Dempsey, W. E.

OREGON

Corvallis
Moore, James Francis, Jr.

Portland
Bell, James Forbes

PENNSYLVANIA

Altoona
Gardner, Ronald

Ashland
Randall, Harradon R.

Bethlehem
Gallagher, Robert Taylor
Howell, Stephen H.

Bradford
Bauer, G. Gerald
Booth, A. E.
Bossler, Robert B.
Breston, Joseph N.
Brewster, Frank M., Jr.
Buckwalter, John F.
Dorn, Forest D.
Heck, E. T.
Landers, David E.
Newton, Richard R.
Paynter, Warren T.
Simmons, Arthur C.
Skinner, Walter S.

Breburn
Schuck, Charles W.

Bridgeville
Kellar, Katherine K.

West Sunbury
Mackay, Joel R.

Erie
Gardner, Bernard E., Jr.

Harmarville
Amero, R. C.

Hazelton
Klotz, R. L.

Johnstown
George, Raymond E.
Mullen, Gerald Ray

Lester
Corson, James A.

Milford
Greening, Allen J.

Munhall
Ramsay, H. J.

Newton Square
Patterson, Omar L.

Oil City
Johnson, F. A.
McClintock, Charles W.

Philadelphia
Allen, Henry Butler
Fitzgerald, A. E.
Gottlieb, B. M.
Hamilton, S. Harbert
Jensen, Homer
Kleiner, Abraham
Knight, E. T.
Laskaris, Lycurgus
McCain, Hugh M.
Pack, Robert W.
Pew, J. N., III
Webber, Charles E.

Pittsburgh
Abel, Raymond L.
Boggs, Robert L.
Botset, Holbrook G.
Bradshaw, Grant D.
Brockett, Ernest D., Jr.
Convers, Frederick L.
Coppula, Fiore W.
Cox, Benjamin Burton
Craig, Albert B.
Ebitz, Frank M.
Endean, Howard J.
Fettke, Charles R.
Fiedler, William M.
Finn, F. H.
Foote, Paul D.
Foster, Alden W.
Frederick, R. Charles
Fulton, Paul F.
Ganter, Robert K., Jr.
Gregory, Alvin Ray
Gulley, M. Gordon
Hamilton, Jack R.
Harris, Donald F.
Heald, K. C.
Henderson, James H.
Hetherington, George, Jr.
Ingham, Albert I.
Jukes, H. R.
Kerr, Arthur J.
Kuhne, Edward B.
Leatham, Earl
Linn, Earl H.
May, Lem G.
McDowell, James Milton
Mears, Robert B.
Meyer, D. W.
Mitchell, G. M.
Morgan, Frank
Morrow, J. D. A.
Morse, R. A.
Murdy, Richard J.
Muskat, Morris
Nicholson, Clyde D.
Nuhfer, Leo R.
Oberle, James Joseph
Perry, H. Stewart
Peters, Charles Jack
Pohoriles, Eugene M.
Powell, Alfred Richard
Pursglove, Joseph, Jr.
Pyle, L. William
Roman, Morton C.
Ruschak, John D.
Ryan, John T., Jr.
Sass, Louis C.
Shiry, Joseph
Shrut, Robert H.
Smith, C. A.
Spangler, C. V.
Sturges, Thomas B.
Swensrud, S. A.
Tully, James J., Jr.
Voekel, Stewart M.
Vollmer, Leslie W.
Wall, John Robert
Walmer, C. Richard
Weidlein, Edward R.
Wescott, Blaine B.
Whiteford, William K.
Wood, Robert S.
Woods, Lawrence T.
Wyllie, M. R. J.
Yant, William P.

Shinglehouse
Holmes, R. C.

Somerset
Wright, H. Stewart

State College
Becker, Frederick L.
Calhoun, John C., Jr.
Channabasappa, K. C.
Culp, Joseph Clair
Gilchrist, Ralph E.
Marsden, Sullivan S., Jr.
McMaster, Charles Glenn
Newman, Robert C.
Nielsen, Ralph F.
Paulsell, W. G.
Preston, Floyd W.
Steidle, Edward
Thomas, Gordon W.

St. Benedict
Peale, Richard

Swissvale
Jelinek, John G.

Washington
Scholl, Erwin S.

SOUTH CAROLINA

Charleston
Dedek, Robert S.
Keilen, John J., Jr.

Columbia
Taber, Stephen

Sumter
Adams, Gilbreth D.

Buffalo
Nation, Dean J.

Milesville
Bierwagen, Elmer E.

SOUTH DAKOTA

Rapid City
Axsell, Charlotte A.
Gries, John Paul
Hayes, Joel P.
Rankin, Rodney

TENNESSEE

Columbia
Downey, Harmon A.

Memphis
Phelan, Stephen

Nashville
Jewell, W. B.

Oak Ridge
Cromer, Sylvan
McCullough, Fred C.

TEXAS

Abilene
Ames, Edward W.
Anders, Ellis L., Jr.
Becker, William Henry
Black, C. V.
Bowen, R. M., Jr.
Brennan, Harry W., Jr.
Bridges, Philip M.
Briggs, Jack M.
Brundred, L. L., Jr.
Buckles, F. C.
Canady, James M.
Cannon, Cecil N.
Carpenter, J. W.
Carroll, Alton J.
Cobb, Henry Edgar, Jr.
Cockrell, Robert B.
Conselman, Frank B.
Cook, Aaron W.
Cook, J. W.
Coppinger, John E.
Corley, D. E.
Coulson, Jack L.
Cree, W. R.
Davis, William W.
Deats, Hollis W.
Dimon, Alfred F.
Doggett, O. G.
Dolezal, W. T.
Dunnam, James
Duffield, Carl E., Jr.
Eickmeyer, Walter A.
Evans, A. J.
Feagan, Richard W.
Fiscus, N. O.
Fitzgerald, Norman D.
Freese, James D.
Germany, W. W.
Gilles, L. A.
Glover, C. A.
Goltz, Eugene M.
Gray, Gordon H.
Greathouse, Myrle
Hada, John L., Jr.
Hammer, Wallace L.
Hammond, Hood
Haney, H. P.

Abilene—*Continued*
Herring, Julian C.
Holly, Lowell B.
Holly, Wilson C.
Hucklebridge, William H.
Hunter, Hassell E.
Hunter, J. C., Jr.
Ice, James H.
James, Jack R.
Jenkins, Joseph B.
Johnson, Harold E.
Jones, Miles T.
Kerley, Cecil L.
Kralis, Dan F.
Lacik, Harold A.
La Rue, Chester R.
Lawless, J. E.
Levy, Irwin L.
Loader, Melvin
Loflin, John Neal
McDermott, W. E.
McLaughlin, D. B.
McNair, Sherwyn L.
Moore, Earl K.
Mossholder, Max V.
Neely, Lemon Grey
Nugent, W. H.
Nussbaumer, Fred W.
Ogden, Victor Benjamin
Parrott, Emory W.
Payne, Bryan William
Payne, Roy D.
Perini, V. C., Jr.
Porter, Will B.
Pratt, P. Ross
Prentice, Robert G.
Putman, B. R.
Rains, William R., Jr.
Ratts, Robert V.
Richardson, William C.
Riddel, Benton
Rogers, W. T.
Rothwell, Charles, Jr.
Russell, James E.
Samuel, John Howard
See, Alonzo B.
Shoemaker, John W.
Sides, Fred C.
Sides, W. G.
Smith, Bertram L., Jr.
Stahl, Frank B.
Stearns, John R.
Stocker, S. H.
Stumpf, Clarence Henry, Jr.
Taliaferro, Scott L.
Taylor, James B.
Thompson, Clyde, Jr.
Thompson, John R.
Thompson, R. W.
Thompson, Richard D., Jr.
Tilton, Rollin J.
Tompkins, J. D.
Vaughan, George H.
Wade, Dell C.
Walker, Guy M.
Wallace, Walter E.
Warren, L. Coy
Webster, L. D.
Wells, H. P., Jr.
West, C. Kenneth
Wester, J. S.
Wheeler, F. Raymond
White, Glenn R.
Whittaker, Don
Willis, V. H.
Wilson, Herbert C.
Womack, Robert J.
Wood, L. M.

Agua Dulce
Brannon, Ben A.

Alamo
Hammett, Ellis T.

Albany
Morgan, John W.

Alice
Andersen, Howard W.
Childress, Charles O.
Cook, Edgar L.
Dillingham, Mike C.
Fair, William Y.
Findley, W. E., Jr.
Fischer, Alfred O.
Flournoy, Lucien
Gallagher, A. C., Jr.
Gibson, Alfred R.
McNeill, H. E.
Olansen, Norman A.
Pall, Anthony T.
Smith, George W.
Staples, Dallas R.
Teal, Alvin P.
Tighe, Thomas J.
Wilson, George S.
Wilson, William W.

Alvin
Finken, Robert E.
Gaither, Orville D.
Hahn, Harvey C.
Hogan, Charles I.
Milner, Charles P.
Ziegler, Alvin E.

Amarillo
Cox, A. F.
Hall, J. E.
Hilliard, William H.
Jackson, Donald W.
Johnson, Dale L.
Kelly, F. Wayne
Knight, Orland Jack Lenard
Lorenzen, Robert M.
Major, John C.
Miller, Raymond W.
Morris, Edward S.
Osgood, Charles E., Jr.
Petsch, Arthur H.
Richardson, J. C., Jr.
Seibel, C. W.
Storm, Frank J.
Watson, Kimball S.
Weichert, E. A.
Whitis, Thurman S.

Andrews
Atnipp, H. L.
Demmler, Eugene
Halvorsen, Robert L.
Helm, Cyrus V.
Hickok, Charles W.
McKendree, Bishop D.
Smith, Wesley W.
Walker, Donald
Wright, Joseph J., Jr.

Angleton
Jackson, John G.

Anna
West, Geo. Wm.

Athens
Barbour, Russell C., Jr.
Crowder, Bert E.
Jordan, James R.
Nixon, B. P.
Orr, Willis P.
Pool, Ray, Jr.
Wheeler, Frank W.

Austin
Barbeck, Arthur H.
Baumel, Jack K.
Breitung, Charles A.
Brown, Carl A.
Byram, Ronald W.
Coker, Mac L.
Crowther, A. B., Jr.
Deford, Ronald K.
Edgerton, George H.
Elam, Frank M.
Elliott, Major John E.
Ellison, Samuel P., Jr.
Endacott, James Harrison
Fancher, Dr. George H.
Gregg, Kirtley J., Jr.
Halbouty, Thomas Joseph
Hall, James A., Jr.
Haughn, Jack E.
Herald, Frank A.
Heuer, George J., Jr.
Holland, William W.
Holloway, Edward D.
Hough, Eldred W.
Jessen, Frank W.
Joyner, Hagan D.
Keithly, Clyde M.
McAlpin, Donald L.
McKetta, John J., Jr.
Miller, Knox, Jr.
Morgan, Jay E.
Murray, William J., Jr.
Nemir, Charles
Newman, Harland E.
O'Dell, Harold
Power, Harry H.
Roebuck, Field, Jr.
Rowan, Arch H., Jr.
Rowland, David A.
Schmidt, Paul W.
Smith, Sol
Soofi, M. E.
Srinivasan, S.
Toktar, Can Naci
Torrey, Paul Dwight

Avoca
Thomas, Frank G.

Ballinger
Perdue, Howard M.

Bay City
Barton, Robert Leslie
Gaudet, Edward W.
Pfile, Robert A.
Young, Richard R.
Young, Roy M.

Baytown
Wellborn, Joseph H.

Beaumont
Biscamp, Roy G.
Bubeck, Allan F., Jr.
Buchanan, F. E.
Busby, Richard O.
Chaney, Preston E.
Chandler, Darrell E.
Cokinos, Geneos Pete
Cornelius, George L.
Denton, Harold
Dibrell, Etheridge
Dowell, George B.
Goodson, James E.
Guerin, Thomas L., Jr.
Hodges, James W.
Junod, William B.
Koehler, Burford R.
Long, A. B.,
Melasky, W. L.
Montague, Kenneth E.
Polk, Roland
Prihoda, Clarence H.
Vest, Oscar John, Jr.
Watson, Ernest D.
Wiess, Byron, Jr.

Beeville
Barnes, Charlie
Cook, A. W. Jr.
Havard, Eugene W.
Kates, James M.
Leggott, C. R., Jr.
Naron, Marshall Ernest
Nesmith, Fred S., Jr.
Prince, N. A.
Senseman, R. B.
Sullins, Charles A.
Syfan, Frank E.
Trostel, Norris H.
Wilshusen, John H.
Zwald, Edwin A.

Bellaire
Bednarski, Valery N.
Coleman, Dwayne M.
Da Roza, Robert A.
Kelley, Arthur L.
Lunceford, Major L., Jr.
Massad, Alexander H.
Sawvel, Glenn C.
Shearin, H. M.
Sherwin, M. W.
Smitherman, Eugene Alston
Steinberger, Calvin C.
Ten Brink, Karl C.
Weiss, Walter J.
Widmyer, Richard H.

Bellville
Simpson, William Ray

Big Lake
Norman, Jack C.

Big Spring
Anderson, Edwin R.
Barnes, Chester F.
Ellis, Charles F.
Holifield, F. Harold
Rollins, J. T.
Stipp, H. C.

Bishop
Lonquist, William C.

Boerne
Coughran, Theodore

Borger
Bendler, Jack C.
Bixler, Robert P.
Brammer, Richard N.
Craig, Charles E.
Evans, S. A.
Garrett, E. V.
Germany, Billy K.
Gibson, James C.
Hanna, Harry C.
Harris, Bob R.
Knox, Albert S.
Scarth, Robert W.
Smith, David E.
Woodward, Clifton C., Jr.

Bowie
Swinson, Charles D.

Breckenridge
Childress, John B.
Crone, B. L.
Derrick, James V.
Ferguson, Floyd
Ford, Thomas A.
Fredenburg, M. W.
Garbutt, George H.
Harrell, Joab B., Jr.
Kaltenberger, L. H.
Kingston, Benson M.
Lancaster, Themious S.
McKinney, Oscar B.
Mergele, Jack E.
Miller, B. I.
Morrison, Paul W.
Paine, Charles B.
Reaugh, Orland H.
Rice, E. G.
Sutton, Cecil C.
White, Vincent C.
Williamson, Jack W.

Brownfield
Buckner, Roy E.
Chilton, E. G.
Darby, E. L.
Erwin, Alfred S., Jr.
Freund, Edward L.
Goble, James H.
Gulledge, M. C., Jr.
Hollingsworth, Frank H.
Johnson, Erd M.
Moore, Jasper A.
Musson, Forrest D.
Randle, Robert C.
Shaw, Harrold E.
Snedeker, Keith D.
Swenson, Stanley D.
Watkins, Elven, Jr.

Brownwood
Hester, Don R.

Burkburnett
Mannas, William J.

Burnet
Miller, Robert P., Jr.

Carrollton
Simmons, M. G.

Carthage
Miller, John R.
Trimble, Rob D., Jr.

Cayuga
Richards, James P.

Cisco
Hitt, Harold L.

Chico
Koontz, R. W.

Clairemont
Willingham, C. W.

Clarkwood
Person, Richard F.
Southerland, Willis H.

Coleman
Boldt, W. W.
Brannon, M. J., Jr.
Cheney, Monroe G., Jr.
Rothrock, Howard E.
Stroop, J. E.

College Station
Amyx, James W.
Bass, Daniel M., Jr.
Bomba, John G.
Boykin, Robert S.
Carter, Robert D.
Crawford, Paul B.
Flock, Donald L.
Francis, Euclid Deroe, Jr.
Fritz, Joe
Goodwin, Robert J.
Grote, Fred R.
Holmes, William L.
Hubble, R. J.
Hubbell, Robert H.
Johnson, F. Sam
Kennedy, Harvey T.
Lieb, Henry P.
Lynch, S. A.
Neale, John William
Russell, William L.
Vance, Harold
Whiting, Robert L.
Wieland, Denton R.
Wilbanks, Bruce A.

Conroe
Cole, Frank W.
Davis, Douglass R.
Harrian, John
McStravick, Peter R.

Kilgore
Metcalfe, Albert G.

Corpus Christi
Allday, F. W., Jr.
Allen, Fraser H.
Armstrong, John N., Jr.
Aubuchon, Pierre M.
Austin, Ellis H.
Barfield, William G.
Bartgis, Guy C., Jr.
Bartgis, R. W.
Bates, R. E.
Becker, B. A.
Beecherl, L. A., Jr.
Bengtson, Claymon C.
Bergman, H. A.
Bielstein, W. J.
Black, C. Wendell
Bodine, Edgard E.
Bowers, Emil F.
Bramlet, Charles L.
Brown, Charles J., II
Brumby, Birto R.
Buck, C. E.
Buckner, Gene E.
Burns, L. Robert
Byrd, William C.
Campbell, John G.
Carlson, Eldon E.
Chamrad, Daniel B.
Cooper, Thadius L.
Crutchfield, John W., Jr.
Culberson, Jack W.
Denman, Richard H.
Dickman, W. H.
Dittlinger, Eugene C.
Drum, W. R.
Duerr, Sidney E., Jr.
Dueser, Frederick F.
Elliott, William D.
Ethridge, Lawrence E., Jr.
Etheredge, Morris L.
Focht, F. T.
Fowler, Zeke W.
Freeze, Burlin E.
Gardner, H. E.
Geffs, C. R.
Gill, William G.
Gilstrap, T. O.
Goatley, James H.
Goodson, William C.
Granberry, R. C., Jr.
Granberry, Raymond J.
Green, Ira C., Jr.
Haeger, Clarence H.
Hagens, Robert C.
Hamilton, A. F.

Corpus Christi—*Continued*

Head, Martin F., Jr.
Hemphill, John W.
Hendrix, James R.
Hicks, James H.
Hitt, Hugh H.
Hood, Gerald R.
Hurd, Robert H.
Hurst, John D.
Jacobs, Charles E.
Johnson, F. A.
Jones, Jack D.
Jones, Wm. S.
Jordan, John L.
Justice, William H.
Keller, Raymond, Jr.
Kellogg, W. C.
Kelly, Patrick Walter
Kirby, John E., Jr.
Kitowski, Charles B.
Kundert, Alden E.
Lamont, Norman
Lawnick, Joseph John
Lee, Bill
Lewis, Donald D.
Logan, C. E.
Lyle, Henry N.
Mantor, Philip
Marler, William R., Jr.
McCarty, R. R.
McCauley, C. F.
McClatchey, G. E.
McCray, John L.
McGannon, M. L., Jr.
McKenzie, Bill
McMahon, James J.
McSparran, Donald K.
Miner, R. C.
Moeller, Lester K.
Moore, Alvan A.
Mueller, Joseph P.
Obenhaus, Gus F., Jr.
O'Rourke, Fred C.
Owens, Frank E.
Owens, Herman, Jr.
Parish, Houston
Peery, Joe A.
Phillips, Ned H.
Pierce, Vinton D.
Plaza, Joseph B.
Prejean, Joseph S.
Pruett, Horton T.
Ramsay, J. E.
Ray, J. B.
Riley, Leo C.
Ring, Kenneth A.
Roberts, Alan P.
Rye, William C.
Sale, R. B.
Sargent, E. C.
Saye, Frank M.
Scibienski, H. J.
Scott, Howard W.
Scott, James C.
Seidel, H. A., Jr.
Shannon, John W.
Shaw, Don F.
Shiflett, W. P.
Slavik, Albert T.
Slavik, Edward William
Smith, Sidney H., Jr.
Snelson, Charles H.
Spears, Gordon S., Jr.
Spies, Walter
Stanley, Henry M.
Staples, G. A.
Stapp, Wilford Lee
Stevens, L. M.
Stewart, James F.
Story, S. A., Jr.
Taylor, Austin B., Jr.
Terrill, Edd, Jr.
Truby, Lester G., Jr.
Tucker, Ivan
Turnbull, Paul R.
Vaughan, H. D.
Vest, Harry A.
Volk, H. W., Jr.
Wallace, Robert R.
Wallace, W. H., Jr.
Warren, Jasper N.
Waters, Warren K.
Watts, C. Arliss
Webb, Austin C.
Wheless, Chester L.
Williams, Weldon E.
Wilson, Phillip M.
Yarborough, Robert W.

Corsicana

Cocke, Robert R., III
Copeland, Clinton M.
Guthrie, Bert S.

Crane

Agnew, J. W.
Albrecht, D. W.
Awezec, John S.
Brown, Alfred D.
Etz, George, Jr.
Junkin, Eben D., Jr.
Wade, Herbert N.

Cuero

Hansford, J. E., Jr.

Daisetta

Bronte, Robert F.

Dallas

Abbott, Seth J., Jr.
Agers, Leo B.
Alford, Joe B.
Allen, Forrest, J., Jr.
Amini, Khodagholi
Anderson, Billy C.
Anderson, K. F.
Armstrong, Gerald T.
Armstrong, James B.
Aronofsky, Julius S.
Arps, Jan J.
Bacon, Thomas S.
Bagwell, Calvin C.
Baker, Leo L.
Bale, Hubert E.
Baron, Arnold E.
Barthelemy, W. F.
Beams, R. J.
Beck, Edward C.
Bednar, W. C.
Bell, F. W.
Bendorf, Stanley G.
Bennett, G. B.
Bethancourt, Raoul J.
Bilhartz, Harrell L.
Blum, Harold A.
Bock, Morris
Boren, Kenneth Locke
Bowen, W. J.
Bowie, William H.
Bradley, Howard B.
Bradley, Robert J.
Brainard, Guy R., Jr.
Brandner, Carl F.
Branson, Uzzell S., Jr.
Braun, Philip H.
Bright, H. R.
Bright, Richard T.
Brown, Augustus B.
Brown, Elton L.
Brownscombe, Eugene R.
Brummett, A. E.
Buck, J. Randolph
Burchard, Frederic L.
Burdine, N. T.
Burrell, Arthur A.
Cable, Edwin D.
Calder, N. Bruce
Caldwell, John L., Jr.
Calhoun, Tom G., II
Cammack, Van R.
Campbell, William M.
Caraway, A. Ed
Carlin, Russell G.
Carlson, Thomas C.
Carr, William Plack
Carruth, Leslie G.
Carter, D. V.
Carter, E. A.
Cash, Floyd L.
Caudle, Ben H.
Chandler, Harold T.
Chapell, Don O.
Chase, Dale O.
Chatas, Angelos T.
Christensen, M. P.
Clardy, Bruce C.
Clay, Thomas W.
Cleary, Tyson, Jr.
Clements, William P., Jr.
Clevenger, Paul R.
Cogswell, Patrick F.
Coldwell, Charles H.
Coles, Burton E., Jr.
Collingwood, Douglas M.
Collins, Francis
Cook, Evin L.
Cooper, James D.
Crichton, Jack A.
Crosky, Robert A.
Cunningham, B. A.
Davis, Henry A.
Davis, Roger H.
Davis, Sidney H.
Deegan, Charles J.
De Golyer, Everette
De Mohrenschildt, George
Dennis, Terence E.
Douglas, Alson H.
Douglas, Norvel
Dunlap, Cleo C.
Dunlap, H. F.
Dutton, C. C. Orr
Dyes, Alvin B.
Edwards, R. Bruce
Edwards, Stacy W.
Elfrink, E. Baird
Elliott, William C., Jr.
Ellis, H. E., Jr.
Ellis, J. Ralph, Jr.
English, Kenneth C.
Erickson, Robert A.
Fagin, Kyle Marshall
Faris, Sam R.
Faulk, J. Hugh
Fennell, Lawrence S.
Fisher, Barney
Flagg, Harry L.
Fletcher, Paul B.
Franks, Bennie L.
Fredd, John V.
Frick, Thomas C.
Fuller, J. S.
Garrett, John E., Jr.
Garrett, Melvin M.
Garwood, Turner G.

Dallas—*Continued*

Gasser, James P.
Gaston, Harry J., Jr.
Gee, Kirby C.
Gibbs, James F.
Gibson, Allen B.
Gill, Eric
Gilmore, Robert B.
Glanville, Charles R.
Gordon, Joseph C.
Gottlieb, Sidney H.
Gould, Ben D.
Graham, Gordon Lloyd
Graham, Joe E.
Granville, E. B.
Gregg, Carroll E.
Grissom, Pinkney, Jr.
Grubb, William E.
Grubbs, David M.
Grubenman, Carl, Jr.
Gunter, John R., Jr.
Haas, J. M.
Hager, Dilworth S.
Hammack, John A.
Hargrave, Austen
Harris, Virgil B.
Harrison, Alton A.
Harter, Clyde C., Jr.
Haskett, E. Irene
Hawkins, M. E.
Haynes, James Morton
Heald, Benjamin C.
Heath, Francis
Heithecker, R. E.
Heroy, William B.
Higginbotham, G. T.
Hilseweck, W. J.
Hinchliffe, William E.
Hodges, Donald N.
Hollabaugh, George R.
Holliday, Harley F.
Hollow, Walter B.
Hollrah, Victor M.
Holzhauser, Earl J.
Horner, William L.
Horte, V. L.
Houston, K. O.
Howson, Frank E., Jr.
Hudson, Charles H.
Hunt, Jack L.
Hutchinson, Charles A., Jr.
Hutchinson, Thomas S.
Ivey, Carl E.
Jackson, Warren J.
Jacobs, John C.
Jeffrey, Thomas J.
Jenkins, Rodman
Jennings, Philip H.
Johnson, John P.
Johnston, Orville C.
Jones, Robert E.
Jopling, Don W.
Jordan, Dewey A.
Karcher, J. Clarence
Keiles, Margaret E. C.
Kelley, Cecil Warden, Jr.
Kelton, Frank C.
Kennerly, Thomas L.
Kern, Charles P.
Kern, Loyd R.
Kerr, Henry P.
Kieschnick, William F., Jr.
Kimbler, Oscar K.
Kingsbury, Sherwood William
Kizer, Curtis A.
Knight, Robert F.
Koch, Robert L.
Koch, Howard A., Jr.
Koepf, E. H.
Kraus, Edgar
Kuhn, Carl S., Jr.
Kullin, Robert R.
Lahee, Frederic H.
Landtiser, Paul Keith
Laroe, Dan M.
Laughbaum, Graydon H.
Lawler, Don M.
Lee, J. L.
Lee, Sidney P.
Leeman, Sam P.
Leeser, Russell E.
Leroy, Robert C.
Lewelling, Henry
Lewis, James A.
Lewis, Vassar E.
Liles, Samuel D.
Lindner, John D.
Litherland, James G., Jr.
Loring, William T.
Lougee, Earle S.
Lowrie, John D., Jr.
MacNaughton, Lewis W.
Madera, Ruford F.
Mainard A. D.
Martin, John Laurin
Matthews Cecil C.
Matthews, T. K., II
McColloch, Lewis C.
McCommons, William E.
McConnell, E. B., Jr.
McCord, D. R.
McCoy, George Y.
McDermott, Eugene
McDonal, Frank J.
McDonald, Harry E.
McElheny, Oscar K.

Dallas—*Continued*

McElroy, Paul De Valle
McFarland, R. S.
McGuire, William J.
McKaye, Maxwell S.
McKeever, James M.
Meadows, Paul
Mealer, Bill J.
Meek, P. W.
Mehan, Joseph A.
Meredith, Carlton
Meyer, L. Joffre
Meyer, Willis G.
Millard, William J.
Miller, Charles C.
Mills, Brad
Mitchell, Joseph A.
Moffatt, Lowell G.
Monkhouse, George S.
Monteith, Edward E., Jr.
Montgomery, Jeff
Moore, Jack W.
Moore, James L.
Moore, Thomas F.
Moore, Wesley W.
Morgan, Charles Gill
Morgan, Neil R.
Mortada, Mohamed
Moseley, Harold L.
Moses, Phillip L.
Murphy, John
Murray, Frederick F.
Murrell, John Herhold
Nathman, George P.
Neighbors, Glen R.
Nelson, M., D., Jr.
Newton, W. W.
Nichols, Earl A.
Noyes, Jonathan A.
Odeh, Aziz S.
Oldham, Albert E.
Oldham, Henry N.
Oliver, Fred L.
Oliver, Mac D., Jr.
Olson, C. R.
Olson, E. A., Jr.
O'Neill, L. P.
Osborne, Paul F.
Otis, H. C.
Otis, Herbert C., Jr.
Owens, Dennis E.
Parker, Charles J., Jr.
Parkhurst, Warren
Patton, E. Charles, Jr.
Pearson, Alvin J.
Peers, H. L.
Pela, E. Cecil
Penner, Robert F.
Philipp, Edward Robert
Pierce, P. E.
Pollard, T. A.
Pool, Robert Frank
Porter, Harold C.
Porter, Phil
Porter, Weldon L.
Potter, Lester T.
Pounders, Cecil M. P.
Price, Vernon
Priddy, Ashley H.
Prutzman, Forrest G.
Pyle, Foster M.
Quayle, Alexander
Rains, Richard K., Jr.
Ramey, Henry J., Jr.
Ransone, W. R.
Ravesies, Paul
Ray, Robert B.
Reed, Dale H.
Reichertz, Paul P.
Reneau, Wilbur E., Jr.
Renfro, Harold Bell
Reudelhuber, Frank O.
Reynolds, John T.
Rhea, A. S.
Rhea, John W., Jr.
Rhodes, Charles L.
Rice, George Baker
Rider, Charles R.
Ridgway, Robert Joseph
Ritts, Howard J., Jr.
Roark, Gene E.
Robbins, Kenneth W.
Roberts, Thomas G.
Robinson, Art I.
Rogers, Earl Wayne
Rollow, Wray A.
Rosaire, E. E.
Russell, R. W.
Sanders, C. Horace
Savins, Joseph G.
Schafer, Jack D.
Schaefer, W. W.
Schoeneck, W. E.
Schramm, Harry B.
Schultz, Frank August
Schwab, Carl M.
Schwarz, Melbert
Scott, Erwin R.
Scott, J. O.
Shaw, D. J.
Shepard, Alva P., III
Shepherd, G. Frederick
Silberberg, Alfred H.
Simon, Dick S.
Sims, W. P.
Sinsheimer, Warren A., Jr.
Skinner, William C.

Dallas—*Continued*

Slobod, Robert L.
Smith, Aurel E.
Smith, Bowman L.
Smith, Duane G.
Smith, E. Randolph
Smith, Gerald L.
Smith, Harold Billy
Smith, Harold D.
Smith, Jack H.
Spencer, Morris G.
Stade, Paul W., Jr.
Stafford, Jerry D.
Stearns, Glenn M.
Steinhorst, Richard, Jr.
Stekoll, Marion H.
Stepp, Vern E.
Stewart, Gladstone, Jr.
Stiff, Henry A., Jr.
Stover, Jerry S.
Strang, William Harold
Strecker, Erwin J.
Strong, John P.
Struth, H. J.
Stuart, Stanley H.
Stults, Arthur C.
Sturdivant, Wilton C., Jr.
Sullivan, Jean Horace
Taylor, Donald F., Jr.
Taylor, Earle F.
Taylor, G. W.
Taylor, Robert W.
Terrell, K. V.
Teubner, W. G.
Thomas, Clifford E., Jr.
Thomas, George L.
Thompson, S. A.
Thronson, Lee J.
Tompson Gilbert C.
Tracy Lloyd E.
Tripp, E. Maurice
Trostel, Everett G.
Trotman, Joshua T.
Trout, Kye, Jr.
Tucker, Charles W.
Turner, Forrest W.
Turner, W. Jones, Jr.
Umpleby, Joseph B.
Upchurch, James O.
Van Meter, Orville F., Jr.
Vickrey, Robert E.
Wahl, Jack
Walke, John E.
Ward, Kenneth W.
Waters, Munsey
Watson, James W.
Watson, John W.
Watson, Reginald E.
Wayman, Gordon S., Jr.
Wells, Zack Martin, Jr.
Wessely, Arthur J.
West, W. F.
Westcot, Frank S.
White, Ebb, Jr.
Whitney, J. W. W., Jr.
Whitson, L. R.
Whorton, L. Preston
Wiederkehr, A. M.
Wilhite, Harold L.
Wilkin, George E., Jr.
Williams, Dan C., Jr.
Williams, G. B.
Williams, R. G.
Wilson, Malcolm E.
Wilson, Malcom E., Jr.
Wilson, Robert
Wimberly, Chester L.
Wisenbaker, John D.
Woerheide, A. E., Jr.
Wolff, Ulrich R.
Woltz, Clifton W.
Wood, J. W., Jr.
Wood, Sam O., Jr.
Woodward, Glen E.
Woodward, Jack S.
Woodward, Joseph B.
Wright, Harrold E.
Wroten, Phillip O.
Wyant, Reece E.
Yamamoto, Roy H.
Yukl, Edward T.
Zimmerman, John R.

Dayton

Florence, Walter W.
Tindol, J. Frank

Delmita

Johnston, Dick C.
Morgan, Jack Allen

Premont

Shepherd, Jim Dale

Del Rio

Ogilbee, William

Denver City

Eissler, Victor C.
McCasland, Leonard
Rovello, Tommy, Jr.
Ruth, Charles N.
Speer, Lynn D.

Devine

Lotspeich, H. L.
Patterson, Glenn W.

Dickinson

Krider, E. B.

Dimmitt

Hastings, Joe R.

Dollarhide
Murphey, John R., Jr.
Worrall, Kenneth E.

Dumas
Davis, Robert R.
Deal, Sam M.
Smalley, Kenneth L.

Eastland
Burke, John Charles
Ervin, P. S.
Gourley, Jack
King, Tyrus R.

Edinburg
Vela, Tomas Alejandro

El Campo
Bouldin, William S.
Gordon, E. Forbes
Kittrell, Norman G.
Rorabeck, George Henry

Electra
Christensen, R. J.
Everett, Rex M.
Harper, Harry E.
Johnapelus, James Tom
Kennedy, Tracy J.
Kihneman, Milton J.
Leach, William H., Jr.
Nelson, John G.
Thomson, Alec N.
Woodruff, Charles C.

El Paso
Albritton, Oscar
Bennett, Jules G.
Carpenter, Andrew H.
Dillon, Robert E.
Grimshaw, William F.
Harper, Charles S., Jr.
Joseph, George
Lance, O. Paul
Mason, John D., Jr.
Patrick, Thomas B.
Ray, Colleen Louise
Vowell, Emily H.

Encino
Die, Roy R.
Glasser, Irwin M., Jr.
Hester, Carl T.
Schnitz, Lewes B.
Tindall, Jack L.

Ennis
Smith, Grover E.

Falfurrias
Blakemore, Frank Glen
Cable, L. G.
Custer, Robert J., Jr.
Eskew, Joe E., Jr.
Hansen, Alvin P.
Lowe, John P., Jr.
Marchal, Jacques H.
Nielsen, Jens P.

Floresy
Jones, N. N.

Forsan
Henderson, Donald L.

Fort Bliss
Lawson, Richard J.

Fort Worth
Adams, F. J.
Allen, Alton C.
Atkinson, Burton
Atkinson, Daniel Olin
Awalt, Charles A.
Banks, William R.
Barber, John B.
Bass, Perry R.
Bayer, H. M.
Berger, Walter R.
Bodin, Jean A.
Bond, Lewis H., Jr.
Bonner, Bobby J.
Bowersock, D. D.
Brook, Edward J.
Brooks, Thomas P.
Brown, G. R.
Byars, Harry G.
Caldwell, Blake M.
Caldwell, Robert H.
Candler, Arthur V. B., Jr.
Carter, Frank Stephen
Chapin, E. L.
Chokas, Mitchell J.
Clark, H. Smith
Clarke, Alex, Jr.
Clarke, Kenneth
Closuit, E. M.
Cone, T. M.
Crutchfield, Graham Peterson
Cummins, Ralph H.
Curtis, Thomas Moberly
Dailey, Homer
Darney, Robert P.
Davis, Jas. A.
Davis, Waymon L.
Dean, Paul C.
De Brine, Bruce E.
Dechman, Dwight A.
Dick, Melvin L.
Dilger, Raymond J.
Disch, John A.
Dominy, Kenneth L.
Donoghue, David
Doyle, Raymond L.

Fort Worth—*Continued*
Duree, Jack T.
Durst, Roy T.
Erwin, R. W.
Evans, John R.
Finney, M. A.
Folmar, L. W.
Ford, George H.
Fuqua, H. B.
Gaines, C. D., Jr.
Gearhart, Marvin
Geffen, Sam E.
Gideon, Leroy
Gillespie, Clarke Barkley
Graham, Robert W.
Greenidge, S. M.
Gregg, Dennis E.
Gregory, Peter Paul
Groginski, Philip S.
Gruy, Henry J.
Guenther, Richard S., Jr.
Handy, Malvin A.
Hardwicke, Robert E.
Harrington, Jimmie D.
Hatfield, Floyd E.
Hatfield, Richard F.
Hill, J. E.
Hill, James Robert
Hines, Robert W.
Hogan, Sam W.
Howard, K. C.
Ince, Henry W.
Ireton, Elmer Taylor
Jagers, J. C.
James, Otis L., Jr.
Johnson, Charles B., Jr.
Jones, Frank L.
Keener, M. Herbert L.
Keller, Wallace O.
Kellerman, Robert Eugene
Kelly, Raymond B., Jr.
Kennedy, Joseph D.
Kyner, Robert R.
Lanfair, A. E.
Lee, Lynn K.
Lewis, J. T.
Life, Warner E.
Lisle, B. Orchard
Little, Thomas Wilson
Loeb-Van Maerssen, Otto
Lovejoy, Joseph B.
Lynn, Bascom R.
Lytle, William James, Jr.
Marshall, J. Howard, II
Maxwell, Joseph C.
McCloskey, Leo E.
McDonald, L. L.
McGinnis, J. O.
McLemore, R. H.
Merkt, Ernest E., Jr.
Metzger, Herbert A.
Miller, R. G.
Minahan, James L.
Moffatt, Murray C.
Monaghan, Robert L.
Moncrief, W. A., Jr.
Mooney, J. R.
Moran, Frank W., Jr.
Morgan, John V.
Netherland, Clarence M.
Nickerson, K. W., Jr.
Nienaber, James H.
Nuss, William Frank, Jr.
Onstott, L. J.
Osmond, Charles H.
Owen, Harrold D.
Painter, T. W.
Peacock, Douglas R.
Peterson, L. F.
Pishny, Charles H.
Platt, George
Pollock, James V.
Raney, Donald R.
Rantala, Raymond H.
Rayford, Vernon L.
Reardon, Patrick H.
Reynolds, Fred S.
Richards, John G.
Richards, Warren B.
Roark, R. E.
Robinson, Reginald L.
Rodenberger, Charles A.
Roe, Ralph P.
Rogers, William J.
Roper, Robert L.
Rowan, Archibald H.
Russell, J. Gordon
Sawyer, Floyd D.
Schaeffer, Willard Ardell, Jr.
Sherrod, Gerald Edward
Shields, Robert C.
Smith, Kenneth L.
Smith, William D.
Sorrells, Warren D.
Stallings, Harold O.
Steanson, Robert E.
Sumner, Cyril R.
Sumner, Thomas B.
Terry, Joe B.
Tesch, Robert W.
Thompson, B. E.
Tripp, Karl R.
Vann, John Rush
Van Zandt, James H.
Vater, James W., Jr.
Vaughn, J. B.

Fort Worth—*Continued*
Watson, Richard A.
Weymouth, T. R.
Wheeler, William T., Jr.
Wiley, Paul M.
Williams, Davis Christopher
Wilson, John H.
Wilson, John H., II

Fort Hood
Herbert, William F., Jr.

Fort Stockton
Atkins, Clinton

Freeport
Beutel, Albert P.
Bybee, Paul D., Jr.
Griswold, Nelson D.

Freer
Barrett, W. J.

Gainesville
Crain, Leon L.
Ellisor, Grover C., Jr.
George, Edward Rush
Helzlsouer, John V.
Lobdell, Seth L.
McGannon, Richard L.
Pitzer, Ernest T., Jr.
Thomas, William T.

Galveston
Murchison, John W., Jr.
Watkins, Raymond J.

Galena Park
Slaybaugh, A. B.

Ganado
Howard, Forrest C.

Spraberry
Tuffly, H. J.

Garland
Erskine, Robert M.

Genoa
Johnston, David

Gladewater
Bivins, Doyle S.
Riggs, Roy B., Jr.
Williams, James A.

Goliad
Ramsey, C. T., Jr.

Goldsmith
Thacker, Jon M.

Graham
Edwards, Bob B.
Maule, William F.
Street, William G.
Walker, Jack W.
Willibrand, Al. F.

Grand Falls
Murphy, Bert H.

Grand Prairie
Sandberg, C. Roger

Greggton
Brown, Norman F.

Hallsville
Dickard, Billie F.

Hamlin
Baker, Billy D.
Dujka, J. P.

Hawkins
Bissell, Harry J.
Ferguson, Dan S.
Ingram, Billy J.
Lawless, Joe L.
Taylor, Roland D.
Wright, J. W.

Henderson
Cox, Loren C.
Driscoll, Vance J.
Forgerson, Carl D.
Nance, C. W.

Houston
Abel, Malcolm D.
Abrams, Albert
Adair, William B.
Adams, Dayne E.
Addington, James F., Jr.
Alcorn, Irwin W.
Alger, Robert P.
Allen, Gilbert G.
Allen, Herbert
Allen, Thomas O.
Allen, Tom M.
Allman, George, Jr.
Anderson, James C.
Andruske, J. A.
Armstrong, Earle N.
Arnold, Charles William
Arnold, Isaac
Atterbury, John H., Jr.
Attra, Harvey D.
Attwell, Leonard L., Jr.
Aufricht, William R.
Ayars, Robert N.
Baboin, Guy E.
Bailey, Charles Woodrow
Bailey, John E.
Bailey, Philip N.
Baker, Robert S.
Baker, William A., Jr.
Bankston, Ford A.
Barber, Clifford F.

Houston—*Continued*
Barbour, Walter Bruce
Barkis, Bruce
Barnhart, Paul F.
Barrow, L. T.
Bartley, Arthur N.
Bartran, D. S.
Battle, Jack L.
Battle, Joel A., Jr.
Bayle, Pierre
Beard, Donald Fay
Beardmore, Herbert F.
Beatty, Robert M.
Beery, Roy F., Jr.
Bell, Olin Grogan
Bellis, Lewis C.
Bennett, E. O.
Beutel, Richard A.
Bible, John L.
Biggs, Robert T.
Bilhartz, James R.
Binkley, George W.
Black, J. P.
Blackburn, Charles L.
Blair, Philip Michael
Blanchard, Andre
Bloom, Benjamin
Blouin, Cecil
Boatright, Byron B.
Bobo, Roy A.
Boccella, Bernard L.
Bohon, William R.
Bonner, Louis Franklin
Booth, Barrett E.
Born, Howard R.
Borror, John W.
Boswell, Henry O., Jr.
Boutwell, W. B., Jr.
Bowman, Wayne F., Jr.
Boyd, W. E.
Boyd, William L.
Bozeman, Jimmy William
Bozeman, John F., Jr.
Bracewell, L. M., Jr.
Bradshaw, James G.
Bravenec, Wallace W.
Bricaud, J. M.
Bridges, R. E.,
Brinker, Tyler
Brinkerhoff, Ira
Brons, F.
Brooks, Clyde S.
Brooks, Fred A., Jr.
Broughton, John W.
Broun, Edwin Conway, Jr.
Brown, Bob Diggs
Brown, Charles W.
Brown, George R.
Brown, Hart
Brown, T. M., Jr.
Brown, William Emmett
Brown, William O.
Bruce, George H.
Brust, Richard Lee
Bruyere, Alan
Buchan, Rudolph C.
Buck, E. O.
Buckley, Stuart E.
Buell, Vincent F.
Bugbee, James McKean
Burkhardt, Joseph A.
Burney, Charles R.
Burns, A. L., Jr.
Bush, Robert E.
Byrne, Barney M.
Cadden, James M.
Cain, Dixon H.
Cain, Lester L.
Cain, Patrick H.
Caldwell, J. A.
Calvert, Cecil H.
Cannon, George E.
Cantrell, C. Duncan, Jr.
Cantrell, Ralph B.
Carey, Hillard W.
Carlton, D. P.
Carter, Keegan
Casey, John M., Jr.
Cashin, D. M.
Cawley, Marion M.
Cawthon, Pete W., Jr.
Chalmers, Joseph
Champion, Frank, III
Charrin, P.
Childs, Wm. L., Jr.
Chisholm, W. Fred
Choate, B. L.
Christanelli, Fred A.
Christensen, P. J.
Christensen, Steven H.
Clark, James Donald
Clark, Norman J.
Clark, Ward M.
Clegg, M. F.
Cochran, Wilson H.
Cockrell, Ernest, Jr.
Coleman, James T.
Collett, J. Daviss
Cook, Harold L., Jr.
Cook, W. H.
Cooke, Claude E., Jr.
Cooke, Milton M.
Cooke, W. F., Jr.
Cowart, David M.
Cox, William P.
Cozad, David J.
Crake, Wilfred St. M. E.

Houston—*Continued*
Cram, Ira H.
Cramer, Alan C.
Crandall, John Roderic
Crawford, Newton W.
Craze, Rupert C.
Crego, William O.
Creigh, John L.
Cretsinger, James H.
Crowder, J. J.
Crowe, Jesse Ovel
Cruce, Raymond V.
Cunningham, Jerry P.
Dannenberg, Richard M., III
Dansby, R. E.
Darley, Henry
Darling, Richard M.
Daughtry, Arthur C.
David, Henry
Davidson, Duval A., Jr.
Davis, Benjamin F., Jr.
Davis, C. Malcolm
Davis, Lamar W., Jr.
Davis, Morgan J.
Davis, Phillip
Davis, Ralph E.
Davis, W. K.
Dawson, L. R.
Dawson, R. A. J.
Decker, Harold
Dedman, Harry L.
De Haven, Robert L.
De Laat, Bart
De Menil, John
Derrick, A. M., Jr.
Deussen, Alexander
Dingle, W. W.
Dixon, Buddy R.
Dobson, R. J.
Dodd, James G.
Dodge, Jay R.
Doherty, W. T.
Doll, H. G.
Domercq, John, Jr.
Donhaiser, John N.
Dublin, J. R., III
Dubrow, Meyer H.
Dumbauld, George K.
Duncan, William B.
Edgecomb, C. R., Jr.
Eicher, H. V.
Elkind, Morris D.
Elliott, James David, Jr.
Elliott, Richard M.
Ellis, D. W.
Ellsworth, Ralph I.
Elmdahl, Ben A.
Elsbury, Joe W., Jr.
Emery, M. N.
Engel, Herman A., Jr.
Epps, Richard K.
Erney, Robert C.
Etheridge, K. E.
Euwer, Maxwell L.
Evans, Henry M.
Everett, Willard B., Jr.
Farrington, William B.
Faseler, E. John, Jr.
Fay, Charles H.
Fenn, Ivan J.
Ferguson, Hershal C.
Ferrel, Russell E.
Fields, C. H.
Fischer, L. F.
Flaitz, J. M.
Floeter, John S.
Fluker, Ralph Hardy
Fohs, F. Julius
Foltz, Ross C.
Ford, F. Dee
Ford, Kenneth B.
Forney, Larry W.
Forsyth, John D.
Foster, James L.
Fowler, H. F.
Fowler, Oliver W.
Fox, Fred K.
Franklin, Robert K.
Franks, Curtis C.
Fraser, Jack R.
Freehling, R. N.
Frier, W. A.
Furen, John E.
Fuson, T. J.
Galloway, James H.
Gamble, J. L.
Ganek, Bruce M.
Gant, Guy W.
Gardescu, Ionel I.
Garner, John H.
Garrison, Allen D.
Garrot, Floyd E.
Gentry, Arthur Alden
George, Walter G.
Getzendaner, A. E.
Gibbs, Joe W.
Gibson, James M.
Gilbreath, Merle L.
Gilkeson, Paul W., Jr.
Gillingham, W. J.
Glanville, James W.
Goebel, Thomas E.
Golden, A. C., Jr.
Goldston, W. L., Jr.
Gollnick, Robert L.
Gordon, Dugald

Houston—*Continued*

Gore, Doyle E.
Graham, Ralph C.
Grandall, Kenneth G.
Grandstra, Barney J.
Gray, George H.
Gray, George R.
Gray, Shapleigh G.
Greer, Cecil B.
Greer, Walton J.
Griffin, James S.
Griffin, Phil H., III
Griffin, Wilber H.
Griffith, Clarence L.
Grosjean, Robert B.
Guest, Henry G.
Gueymard, A. G.
Haddox, R. P.
Hagen, Cecil V.
Haines, Frank S., Jr.
Haines, Harry W., Jr.
Halbouty, Michel T.
Hamman, John, Jr.
Hansen, Raymond S.
Harlan, Don L.
Harlan, William Thomas
Harrell, John K.
Harris, J. Wylie, Jr.
Harrison, J. B.
Harrison, Robert W.
Hartung, George H.
Hasselmann, Karl F.
Hatfield, Arlo C.
Hawthorn, David G.
Heinen, Lawrence E.
Hellums, Earle C.
Henderson, Joseph M.
Hendrickson, J. F.
Hendrix, Norris W., Jr.
Henslee, W. A.
Herring, Lafayette B.
Herzog, Gerhard
Hill, Ernest Clifton
Hill, Erwin F.
Hill, Harold J.
Hillhouse, James D.
Hillyer, Richard Ward
Hilton, Paul E.
Hinds, Richard F.
Hinson, Howard H.
Hinton, C. Marks
Hobbs, Melvin X., Jr.
Hoch, Robert S.
Hocott, C. R.
Hodges, Clifford H., Jr.
Hodges, Mose D.
Hogan, Roy E.
Holden, George B.
Holden, James E.
Holloway, Harry H.
Holman, Oscar Keith
Holman, Russell W.
Holmes, John B.
Hood, J. W.
Hopkins, Howard F.
Hopkins, W. B.
Horst, R. D.
Horvitz, Leo
Hotze, Ernest G.
House, Glenn C.
Howard, David S., Jr.
Howard, Lewis B., Jr.
Hoyt, Berton
Hoyt, John L., Jr.
Hubbard, E. P.
Hubbard, Robert Ellis
Hubbard, William E.
Hubbert, M. King
Huber, Theodore A.
Huebel, Leon W.
Huff, R. B.
Hughes, Richard V.
Hungerford, Ernest T.
Hunter, Felix A.
Hurst, William
Ikins, William C.
Ivy, John S.
Jackson, Frederick G.
Jackson, James L.
James, Nelson H.
James, Robert K.
Jax, Jerry R.
Jay, W. R.
Johnson, H. O.
Johnson, Wayne J.
Johnston, Guy H.
Johnston, Richard E.
Jones, Ben L.
Jones, J. T.
Jones, Park J.
Joplin, John L.
Jordan, James K.
Judson, Sidney A.
Jung, Robert A.
Kail, Ray S.
Kantzer, Basil P.
Karpos, George
Kawas, Jesus B.
Keating, Thomas W.
Kehn, Donald M.
Kenneday, John W.
Kern, Curtis R.
Kerr, Raymond A.
Kerver, John K.
Kimmel, Marion L.
Kingelin, George G.
Kinley, John C.

Houston—*Continued*

Kirkpatrick, Charles V.
Kneale, Wm. G.
Kobayashi, Riki
Kokesh, Frank P.
Kolb, Robert H.
Kollar, Ray Eustace
Kraemer, M. Scott
Krause, Henry M., Jr.
Krch, M. F.
Kribs, C. J.
Krueger, William F.
Ladd, Richard F.
Laird, Joe A.
Lancaster, Edgar H., Jr.
Langford, Charlie M., Jr.
Lasky, Bernard H.
Lavery, Carl C.
Lawhon, Charles P.
Leavenworth, Paul B.
Legrand, W. H.
Leisk, Charles W.
Leonardon, Eugene Gilbert
Leverett, W. H.
Levine, Joseph S.
Levy, Arthur G.
Lewis, James E., Jr.
Lewis, Ray C.
Lewis, Russel
Liese, Milton G.
Lindauer, Robert Lee, Jr.
Lipson, Leonard B.
Lloyd, John M., Jr.
Lolyd, Samuel H., III
Logan, Robert V.
Loper, Prentice B.
Louden, Edgar W.
Longley, Arvel J.
Luffel, Donald L.
Lunstroth, Klaus
Lyons, Richard T.
Mackey, James L.
Malloy, Thomas B.
Malott, James P.
Manry, Leon V., Jr.
Manville, Mahlon F.
Markham, H. B.
Marr, John D.
Marr, R. C.
Martin, Clyde A., Jr.
Martin, Earl P.
Mason, William D., Jr.
Matthews, C. S.
Mattingly, P. A.
Maxwell, Curtis F.
Mayfield, M. Laverne
McAfee, Robert V.
McArthur, Arthur A.
McArthur, Harvey K.
McCardell, William M.
McCarter, William Blair
McCarty, Dana G.
McCollum, L. F.
McConnell, Leo V.
McCulloch, Thomas B.
McDannald, Robert Morris
McEntee, J. Robert
McGhee, Edwin
McGonagill, Frank E., Jr.
McGowen, Harold E., Jr.
McNeely, Branch M., Jr.
McNeese, Craig L.
McNeill, Earl L.
McQuown, John H.
Medders, W. L.
Mendell, W. T.
Meredith, Byron
Michaux, Frank W.
Milburn, John D.
Miller, Ernest B., Jr.
Miller, Leland H.
Miller, Martin G.
Miller, Richard K.
Miller, Walter H., Jr.
Milz, Elmer A.
Miner, W. H.
Mitchell, George P.
Mitchell, Robert B.
Modgling, Tom
Moehlman, Robert S.
Moir, John
Montgomery, James Campbell
Montrose, M. E.
Moody, R. A.
Moore, W. D.
Moran, Joseph P.
Moredock, S. K., Jr.
Morgan, Bryan E.
Morgan, Thomas H.
Morris, W. D.
Morrow, Richard M.
Morse, Roy Robert
Moye, John L.
Mulcahy, Harold G.
Mullinax, James A.
Mullins, John D.
Murphy, George W.
Murphy, John A.
Murphy, P. C.
Murray, Edward E.
Murray, John R.
Myers, John C.
Naylor, Roger A.
Neath, Robert A.
Nestle, A. C.
Neuhaus, Ralph

Houston—*Continued*

Newlin, Floyd Koenig
Newman, John A.
Newsome, Joel Arthur
Nice, Frank A., Jr.
Nicodemus, William F.
Norris, N. E.
Nye, George L.
O'Bryan, John D., Jr.
Ocheltree, T. M.
O'Donnell, Lawrence
O'Leary, George
O'Leary, George M.
Oliphant, S. C.
Olive, Marion D.
Omelchuck, Alfred
O'Neill, Haylett, Jr.
Osoba, J. S.
Otell, Harry E., Jr.
Ottenhouse, William
Otto, Herman A.
Owen, Kenneth Dale
Palmer, A. B.
Parish, Robert U.
Parkans, Sidney A.
Parks, A. S.
Parks, Mercer H.
Parks, Robert H.
Parsley, Joe M.
Patrick, Donald J.
Payne, L. L.
Peaceman, Donald W.
Pearce, Sam
Pearce, William A.
Pearson, Gerald T.
Pennington, John V.
Pennington, Thomas, Jr.
Perkins, Frederick M., Jr.
Perricone, A. Charles
Perry, Douglas
Persons, John V.
Phillips, Charles E.
Phillips, Edward R.
Pickles, W. M., Jr.
Pierce, Aaron E.
Pigue, Paul W., Jr.
Pilcher, M. J.
Porter, James W.
Poyner, Herbert F., Jr.
Poythress, Sam J., Jr.
Prell, F. M.
Priest, Gerald G.
Prokop, Charles L.
Pullin, George W., Jr.
Puls, W. L.
Purcell, W. R.
Quinn, Julian W.
Rabson, George H.
Rachford, Henry H., Jr.
Radack, Edmund A.
Ragland, Douglas
Rainey, David H.
Ramage, Bruce G.
Ramby, R. L.
Randall, Donald H.
Randall, Robert V.
Rankin, Horace A.
Rassinier, Edgar A.
Rau, Robert J.
Ray, M. L.
Ray, Robert H.
Reddie, William A.
Reed, Charles M.
Reed, Edwin M.
Reed, L. S.
Reistle, Carl E., Jr.
Reiter, Wilhelm Arthur
Remick, David B.
Ribe, Kenneth H.
Rice, Leon, Jr.
Richardson, Joseph G.
Rickard, James Alexander
Ridley, Robert P.
Rieke, Robert R.
Riggs, Thomas A.
Risien, Harvey V.
Roberts, Amos A.
Roberts, E. A., Jr.
Roberts, Eugene C.
Roberts, O. Alan, Jr.
Robertson, Glenn D.
Robertson, Lake, Jr.
Robinson, L. H., Jr.
Robishaw, Earl J.
Roepke, Russell L.
Rolshausen, F. W.
Roof, Jack G.
Ross, Edwin
Ross, Joseph A., Jr.
Rowan, Robert Livingston, Jr.
Rumble, Robert C.
Runion, Felix A.
Ruska, Walter E. A.
Russell, Clarence A.
Russell, Donald Glenn
Russell, George F.
Rust, William Monroe, Jr.
Rutledge, R. M., Jr.
Sagoci, Hilmi F.
St. Germain, Raymond J.
Salathiel, Richard A.
Sanders, Wilfred E.
Sandoz, Theodore H.
Saville, W. G.
Sawtelle, G. Flint
Sawtelle, George

Houston—*Continued*

Scamman, Charles W.
Scarborough, William E.
Schilthuis, Ralph J.
Schlumberger, Pierre
Scott, F. L., Jr.
Scott, W. Blair, Jr.
Scrafford, Bruce
Seely, Dwight H., Jr.
Selig, A. L.
Seward, D. C., Jr.
Shearer, Louis H.
Sheets, Martin M.
Sheffield, Hugh D.
Shelton, John E.
Shelton, William F.
Sherar, Stuart
Shively, C. Wayne
Shook, Austen M.
Sick, J. Edward, III
Sides, John M.
Sikora, Vincent J.
Simmons, James M.
Simpson, Harold
Simpson, Jay P.
Simpson, John M.
Simpson, Ray E., Jr.
Sinclair, John Taylor, Jr.
Singletary, Frank
Sloan, J. Paul
Sloan, Laurie M.
Smith, Erwin Weir
Smith, John T.
Smith, William C.
Smith, William David, Jr.
Smith, William P.
Smith, Winston Glenn
Spain, Horace H.
Spoor, H. C., Jr.
Stallworth, David C.
Stamm, Henry E., III
Stampley, Bonner Orris
Stanwood, Roger D.
Statton, James N.
Stevens, Albert B.
Stillwell, K. L., Jr.
Stone, Herbert L.
Storer, Todd C.
Stratton, Everett F.
Suder, Floyd E., Jr.
Sullaway, Guy B.
Suman, John R.
Suman, John R., Jr.
Sutherland, W. D.
Sutton, Chase E., Jr.
Swan, Lester B.
Swan, Wilson B.
Swigart, Theodore E.
Sybert, Jack H.
Sydow, C. H., Jr.
Talbot, J. S.
Tausch, Gilbert H.
Taylor, Ralph E.
Teague, J. U.
Teas, L. P.
Templeton, Charles C.
Tennant, Joseph A., Jr.
Terry, W. M.
Tharp, Joshua M., Jr.
Thies, Roland K.
Thomas, Bowman
Thrash, Purvis James
Tighe, Louis T.
Tixier, Maurice P.
Todd, John D.
Toelke, L. W.
Toler, William D.
Tower, Dudley
Treichler, H. E., Jr.
Tribble, Robert G.
Trube, Albert S., Jr.
True, Martin E.
Tschirley, Norman K.
Tulloe, A. R.
Uhrig, L. Vernon
Umpleby, Stuart S.
Underwood, James R., Jr.
Van Burgh, Lisle R.
Van Dyke, Orien
Van Everdingen, A. F.
Van Fossen, Gordon
Van Siclen, De Witt Clinton
Van Slyke, Leonard D.
Varnell, D. D.
Vaughan, William H.
Vietti, William Victor
Vogel, Felix A., Jr.
Voigt, Harold E.
Van Rosenberg, Dale U.
Waddill, Alfred W.
Wadlington, D. R.
Wagenecht, Eugene G.
Walker, John Wm.
Walker, Robert J.
Wansbrough, R. S.
Ward, Robert Dee
Warner, Charles A.
Warren, Howard C.
Waterman, Logan C.
Waters, George W.
Watson, J. P., Jr.
Wear, John M.
Weaver, Earl M.
Weaver, Paul
Webb, Sam N.
Webster, Joe T.

Houston—*Continued*

Wege, J. Milton
Weiler, James F.
Welch, W. T.
Welsh, James R.
Welsh, Le Roy G.
Whaley, Newton P.
Wheeler, J. D.
White, Gordon H.
White, William E., Jr.
Whitis, Emett D.
Whitson, Robert E.
Wickstrom, Stanley A.
Widner, George W.
Wight, George C.
Wilbanks, Hugh, Jr.
Wilde, Henry Dayton
Wiley, Charlie W.
Williams, C. R.
Williams, Charles Edwin, Jr.
Williams, John W.
Williams, Milton
Wilson, Ernest B.
Wilson, James L.
Wilson, Ralph W.
Wilson, Wallace W.
Winkler, Herald W.
Winsauer, Weldon O.
Wise, Fred N.
Withers, William T.
Wolf, Alexander
Wooden, M. M.
Woodling, F. E.
Woodruff, F. Norman
Woods, H. B.
Woods, Rex W.
Woodward, Robert J.
Wooley, Carey J., Jr.
Woy, John Charles
Wright, Alvin P.
Wright, Paul C., Jr.
Wrightsman, Gilbert G.
Yale, William D.
Zeid, Marvin C.

Iraan

Barker, Donald B.
Black, William A.
Chiles, Harrell D.
Howell, David P.
Morris, Drayton E.
Smith, Wilburn M.
Waggoner, Jack N.

Irving

Jenkins, Ralph E.

Jacksboro

MacFarlane, James L.
Welch, H. E.

Kamay

McBride, Donald S.

Katy

Enochs, Philip B.
Evans, Billy Wayne
Knopp, Charles R.
Langner, C. A.

Kermit

Ehlers, Peter L.
Gallas, D. Otis
Krottinger, Ralph L.
Pulte, John E.
Schaeffer, Willard A., III
Tibbets, Bill J.

Kilgore

Bass, Robert W.
Bradbury, R. M.
Burton, James G.
Butts, James A., Jr.
Cameron, John S., Jr.
Crowder W. T., Jr.
Davis, B. M.
Dial, Louis H.
Elbel, Jacques L.
Emrick, Omar Lee
Foster, J. M.
Goodrich, John H.
Happel, Philip E.
Hess, Robert M.
Hoffmann, Frank J., Jr.
Kemp, Gore
St. Laurent, C. P.
Lehnhard, Phil J.
Long, H. L.
Miller, Robert Nall
Morris, Winfield S.
Neely, A. B.
Pierce, John E.
Reed, M. L.
Roux, Gus L.
Scheirman, Gene L.
Sole, William G., Jr.
Stamos, Charles J.
Tarbel, Brook Dawson
Tyler, Winston D.
Van-Os, Seymour, Jr.

Killeen

Vague, James R.

Kingsville

Carothers, Campbell M.
Case, Edward M., Jr.
Dotterweich, Frank H.
Dyke, Peter M.
Eskew, James Oliver
Gibson, Charles M.
Grimes, Milton Ray, Jr.

Hand, Leroy
Kennedy, Seth L.
Wooddy, Lemuel Dale, Jr.
Wright, H. T.

La Porte
Sinclair, Thomas G.

Laredo
Calohan, William Frank
Kirkpatrick, R. R.

Levelland
Gillham, James A.
Jones, Charles W.
Meadows, Paul D.
Rippetoe, Robert M.
Wadlington, William H.

Liberty
Barr, David R.
Brown, James T.
Drushel, W. H.
Perilloux, Charles J.
Straw, Henry F.

Longview
Bander, J. H.
Brashear, C. A.
De Moss, A. C.
Farris, James C.
Miller, Herbert Dell
Pearson, Ralph E.
Springer, Sam E.
Tallant J. L. Jr.

Lone Star
Johnson, Charles Harold
Ottman, Eric J.

Lubbock
Anthony, Bob G.
Anthanas, Gus
Barfield, Edward Collyns
Benischek, Howard William
Blackaller, E. H.
Clark, Joe R.
Conine, J. H.
Cotey, Bradford J.
Ducker, William L.
Fowler, James E.
Griffin, Billy C.
Hinchey, John Raymond
James, Allen A.
Johnson, Philip
Klaus, Hellmut
Lemon, Richard Frank
Livermore, George P.
Livingston, Jennings B.
Ochsner, John D.
Samuel, Julian M.
Wade, Franklin A.

Lufkin
Little, Lloyd A.
Trout, Walter W.

Lyford
Green, Francis L.
Thompson, Richard D.

McAllen
Birdwell, W. Russell, Jr.
Brady, Harold J.
Britsch, Clinton H.
Buckley, James R.
David, James M.
Diehl, Keith L.
Ely, Edgar L.
Hardaway, Rex L.
Kosarek, Charlie John, Jr.
Lancaster, Gordon G.
Nichols, C. R.

McCamey
Wintle, J. V., Jr.

McGregor
Inman, Arthur E.
Moon, John A.

McKinney
McCarley, Robert E.

Merkel
Hanson, Torlif
Loflin, W. M.
Moore, Dalton, Jr.

Midland
Anderson, Eldon D.
Anderson, E. T.
Atteberry, D. R.
Babitzke, Ernest H.
Bachman, William S.
Banister, Richard C.
Barney, Charles L.
Barrett, Jean M.
Barsachs, Edwin H.
Beal, Carlton
Bee, Dan A.
Berger, Walter R., Jr.
Blackwood, James C.
Brack, John R.
Branch, William H.
Brantly, M. McGehee
Brown, B. J.
Brown, Donald C.
Brown, Richard L.
Bruno, Earl R.
Bundrant, C. O.
Burnett, Peter G.
Bynum, Rufe S., Jr.
Byrd, Alvis O.
Byrd, Lawrence H.
Campbell, Tom B.
Carr, C. H.

Midland—*Continued*
Cawley, Aaron
Chiles, H. E., Jr.
Clark, Roscoe C., Jr.
Cocanower, R. D.
Coe, Raymond H.
Conover, George E.
Coone, Malcolm G.
Cooper, Cyril G.
Courter, C. N.
Cox, Johnnie L.
Crawley, James B.
Crews, O. H.
Crittenden, J. L.
Crothers, William L.
Cummings, V. M.
Daly, George D., Jr.
Dewey, Robert S.
Donnelly, Alden S.
Douglass, Frederick D.
Downs, Stanford L.
Drisko, Phillip B.
Duff, Thomas H.
Durham, E. N.
Eaton, John R.
Edwards, F. Clinton
Edwardson, Merrill J.
Einarsen, Charles A.
Evans, John R.
Fitting, R. U., Jr.
Fitting, Robert D.
Foster, Lynn E.
Fox, W. C.
Franklin, Leonard O.
Fry, Bill H.
Gillett, Dan
Gilmore, W. H., Jr.
Goode, William W., Jr.
Goodrich, Alton C.
Gordon, Reynolds V.
Graybeal, J. W.
Griffith, W. F., Jr.
Grossman, Waldo L.
Grove, Donald E.
Guernsey, Arthur Taylor
Haggard, Archie Karl
Hahn, Walter L.
Haigh, Berte R.
Hardee, Peck, Jr.
Harris, Harold M.
Harrison, Charles M.
Hassell, Tom W.
Hayes, James C.
Henderson, G. H.
Henderson, W. Dave
Hess, Donald W.
Hibberts, Charles R.
Hillhouse, Gordon E.
Hills, John M.
Holland, Henry K., Jr.
Horton, William McKee
House, John W.
Howard, Joe R.
Howard, Raymond E.
Hoy, George R.
Hurst, Robert E.
Huzarevich, Julian E.
Johnston, W. R.
Jones, Crandall D.
Jones, J. Robert
Jonsson, Philip R.
Judson, Edward H.
Kearley, W. M., Jr.
Kelly, Edward F.
Kindsvater, Paul A.
Kirk, Rufus P.
Kitley, Dayton V.
Knight, Eugene M.
Knox, John A.
Kunkel, George C.
Landreth, George H.
Landun, Harvin L.
Lap, P. O.
La Roche, William E.
Leach, Steven James
Lebeaux, J. M.
Leibrock, Robert M.
Lewis, Maurice, Jr.
Lindsey, H. E., Jr.
Locke, L. C.
Loeb, Herman
Loper, Raymond G.
Major, Rufus O.
Malone, Billy C.
Mannon, Alfred T., Jr.
Markolf, J. B.
Martin, William H.
Matthews Thomas A.
Maverick, Phillip
Maverick, Phillip, Jr.
McCaskill, Neal
McClellan, J. B.
McDaniel, Gene E.
McDonnold, S. S.
McKaskle, H. G.
McLaughlin, James F.
McMillian, John G., Jr.
Mercier, Vincent J.
Meurer, Marcus C.
Montgomery, Stuart
Moore, Jack M.
Moore, Joe L.
Moriarty, Kenneth D.
Myers, Jack P.
Neely, Robert E.
Neill, George H.
Neuman, J. V., Jr.

Midland—*Continued*
Nicolais, Anthony L.
Oglesby, G. A.
Owens, William D.
Pate, William
Penn, William Y.
Perusek, Cyril J.
Pierce, Edward J.
Plumb, Leslie B., Jr.
Precise, Jack F.
Qualin, Charles F.
Qualls, Robert C.
Ramsey, D. E.
Randerson, Luther W.
Ray, E. B.
Red, J. B.
Rike, J. L.
Rippey, R. L.
Risley, Edyth
Russell, Maynard W.
St. Clair, Donald W.
Schalk, Thomas S.
Schmalz, J. P.
Schreiber, William Thomas
Schrenkel, Jack
Sehnert, H. G., Jr.
Senning, Robert C.
Shakely, Ed
Sheehan, J. A.
Simon, G. D.
Simpson, Julian M.
Sinclair, Bruce A.
Sindel, Albert T., Jr.
Siverson, Robert E.
Smelser, Edward O.
Smith, Ray P.
Speers, Fred H.
Stephens, Robert M.
Steuer, Neil B.
Stewart, Robert E.
Stewart, Vernon R.
Stites, Wilbur D.
Stitt, Ira B.
Swaim, Howard W.
Sweeney, Henry N.
Tinslar, William L.
Trobaugh, Allen K.
Tucker, E. E.
Vernor, Bruce
Vogel, Alfred J.
Wahlstrom, Edwin A.
Walker, William C.
Walsh, Alva G.
Wendt, H. Edward
White, Ven O.
Wilkinson, Walter M.
Williams, James M., Jr.
Williams, Thomas C., Jr.
Wilson, Merrill B.
Wintle, Thomas H.
Wood, Jack S.
Wood, Lestor B.
Wooldridge, C. E.
Wright, Fred S., Jr.
Wynn, W. Turner
Younger, John F.

Mineral Wells
Kruger, Weldon D.

Monahans
Hostetler, John C.
Orr, Robert Mitchell
Powers, Walter D.
Ward, Theodore G., Jr.
Watson, Marsh S., Jr.

Monroe City
Brown, Harry W.
McReynolds, James H., Jr.

Mt. Vernon
Irby, Tom L.

Nederland
Streetman, Jack D.

Newgulf
Zemanek, Arnold F.

New London
Moore, Clint

North Cowden
Allen, Warren I.
Courtright, Raymond O., Jr.

Odem
Killins, Charles R.

Odessa
Adams, Wayne R.
Attix, Edwin W.
Bernard, Howard J.
Bishop, Bryan
Bolick, Max A.
Brackbill, R. M.
Brewer, Ross A., Jr.
Carpenter, A. L.
Casey, Edward H.
Cherry, James C.
Clarke, Richard E.
Cloughly, Ernest M.
Croft, Leland R.
Cross, Jonathan H., Jr.
Crowl, Charles W.
Czirr, Don L.
Donnelly, Richard
Dow, William A.
Dressen, William F.
Elsey, Harry N.
Eubanks, Jerry
Faris, Dwight J., Jr.

Forster, Fred E., Jr.
Goodnough, Stephen C., Jr.
Gordon, Jack F.
Graham, John V.
Greene, Page O.
Gude, Leo J.
Hallford, John D.
Henderson, James C.
Hewitt, Donald E.
Hippard, R. M.
Kading, H. W.
Kastner, Donald L.
Keil, Byron L.
Kennerly, Kenneth S.
Kidd, Thomas Wayland
Kirkpatrick, R. P.
Lovelady, I. W.
Lowary, Thomas B.
Main, Marion K.
McLaughlin, J. D.
McLean, T. O.
Merryman, C. J.
Moriarty, F. W.
Nichols, Thomas J.
Ormond, James F.
Patterson, Harold L.
Powell, Walbridge J.
Rodman, Earl G.
Russell, Jack R.
Schuelke, John N.
Seaman, Charles K., Jr.
Shilcutt, C. E.
Showen, Ellsworth W.
Slaughter, Ernest, Jr.
Smotherman, Harold M.
Stephenson, John Wayne
Swearingen, Dale D.
Thrash, John Curtis, Jr.
Walker, Robert W.
Williams, Jack C.
Wright, Lloyd C.
Young, William Blake

Otischalk
Sanders, John Loren

Overton
Lawless, Fred E.
Sullivan, Bruce M.
Williams, Roger J.

Palacios
Trull, Robert B.

Palestine
Dommersnaes, Orland
Henderson, Charles L., Jr.

Pampa
Abouhalkah, T. A.
Adcock, Fred H., Jr.
Angstadt, Raymond R.
Carroll, Joseph C.
Culwell, W. D.
Daniel, Joe M., Jr.
Graham, James W., Jr.
Grommon, P. D., Jr.
Jacob, Fred L.
Matejowsky, William O., Jr.
Matlock, James D.
Milliren, Leroy L.
O'Quinn, Percy C.
Osborne, E. F., Jr.
Radtke, Donald E.
Rose, Henry J.
Ross, Leroy C.
Savary, George A.
Sellers, Leslie M.
Sheldon, John A.
Sidwell, Eugene R.
Simmons, William T.
Stein, Walter F. G.
Stewart, Harold A.
Stone, James H.
Veazey, Edward J.
Wallace, Harry J.
Walsh, Chas. W., Jr.
White, Leonard L.

Pasadena
Daffin, Douglas E.

Pearsall
Brownlee, Curtis M.

Penwell
Allen, Loy F.
Ayers, Marion L.

Pettus
Jones, Edward N.

Pharr
Myers, Charles E.

Phillips
Gomme, Robert V.
Phillips, Willis W.
Ziser, J. A.

Pierce
Walts, Charles W.

Pickton
Crowe, William H.
Elliott, Kelly
Frazier, Marvin D.

Pleasanton
Lee, R. J.
McDaniel, Alan Rhodes
Weatherby, W. P.

Port Lavaca
Dye, C. C.

Post
Wall, Earl E.

Premont
Hutchins, Charles H.
Tucker, James W., Jr.

Raymondville
Hill, Harry B., Jr.

Refugio
Adrian, Horace F.
Chesney, Alfred J., Jr.
Cockerham, James L.
Cullinan, Harvey J., Jr.
Tonkin, Robert G.

Richmond
Treichler, H. E.

Rio Grande City
Olson, Mark
Young, Milton

Robstown
Thompson, D. C.

Rotan
McCombs, Winfred

Royalty
Hembree, Loy M.
Thompson, J. A.

San Angelo
Carpenter, Meade A., Jr.
Gregory, J. N.
Griswold, Edward H.
Tyler, Henry Allen, Jr.
Vaughan, George H.
White, Glenn R.

Saint Jo
Terry, H. J., Jr.

San Antonio
Adair, John Kay, Jr.
Bakke, W. E.
Barry, Jack C.
Beckcom, Hugh W.
Bommer, Cleon L.
Bone, Jack A.
Brewer, Robert P., III
Caran, John G.
Coates, George H.
Crosby, G. E.
Dauchy, Joseph H.
Davis, Field M.
Davis, Thornton
Donzis, Jerome M.
Drews, Charles L.
Dunlap, B. H., Jr.
Edwards, Fred F.
Geddie, Ivan D.
Green, Guy E.
Greene, Thomas James
Guerrero, Erasmo T.
Guthrie, R. K.
Hammond, Weldon W.
Holcomb, James A.
Kline, Loren E., Jr.
Koenig, Louis
Kotara, Lambert Steve
Lang, Carl D.
Lewis, Eugene T.
Lipstate, Eugene
Loring, Richard R.
Magne, L.
Makhuli, Elias N.
Mattei, Joe B.
McGee, Charles J.
Moore, Arnold R.
Moore, Clarence E.
Moore, Paul J.
Montgomery, J. M.
Neal, Leslie R., Jr.
Parker, Joseph B.
Pavlovic, Robert
Petty, Dabney E.
Petty, Olive Scott
Quesenbury, William B., Jr.
Renfro, Heath
Richards, William E.
Rochon, R. W.
Rowden, Dale H.
Schimmel, G. R., Jr.
Schmidt, Karl H.
Schoolfield, Ray Floyd
Schutz, Charles D.
Shaw, S. F.
Sidwell, J. H.
Spice, William H., Jr.
Storm, Richard R.
Swearingen, Judson S.
Thomen, George H.
Tower, John R.
Vagtborg, Harold, Jr.
Warner, Ralph E.
Warner, Thor
West, Robert V., Jr.
West, Thomas S.
Winslow, Harry C., Jr.

Santa Anna
Blue, John H.

Seagraves
Simmons, Charles M.

Seminole
Beckelhymer, R. L., Jr.
Boone, Daniel E.
Dyson, Arthur J.
Enloe, Joseph R., Jr.
Sims, Byron O., Jr.

Sherman
Sasser, Floyd, Jr.
Simmons, Jack, Jr.

Silsbee
Edmonds, B. J. G.
Harris, W. Irving Jr.
Zimmermann, Richard L.

Silver
Broocks, W. R.
Covington, Thomas E.
Hornback, Clyde V.
Martin, Ewell B., Jr.

Sinton
Fisher, Gordon H.
Harding, Henry W., Jr.
Mistrot, G. A., III

Snyder
Aldridge, Edwin E., Jr.
Avant, Doyle R., Jr.
Bare, Charles L.
Elliott, Harry W., Jr.
Green, Nathan E.
Jacobs, Robert E.
Jean, Joseph W., Jr.
Kincaid, James L.
Lewis, Tom G.
Lipstate, Philip H., Jr.
Quinlan, Vincent L., Jr.
Schulz, E. B.
Swan, Charles A.
Thomas, Jim B.
Thurman, Earl G., Jr.
Vestal, William A.
Weyel, Elmo G.
Young, Gerald S., Jr.

Stinnett
Pierce, Albert R.

Stowell
Crenshaw, Willis P.
Jenkins, Walter L.

Sullivan City
Christian, Horace R.

Sundown
Allen, Frank, Jr.
Boren, Robert James
Gould, John, Jr.
McGaugh, Thurman E., Jr.
Sweitzer, Paul D.

Sunray
McKinzey, John L.
Rabalais, Melford F.

Sweeny
Coleman, Jack Flowers
Hargis, Jesse W., Jr.
McCann, William R.
Mitchell, B. E., Jr.
Murray, James W.

Sweetwater
King, Glenn W.
Paxton, J. W.
Swanson, Charles H.

Talco
Howard, Glenn O.
Winchell, Donald H.

Thompson
Cox, James A.
McDuffie, John C., Jr.
Suman, Richard H.

Tokio
Gregory, Scott H.

Tomball
Ehrhardt, C. D., Jr.

Tyler
Arnold, James W.
Calvert, John G.
Clark, William H.
Corley, Charles B., Jr.
Cotton, J. M.
Craig, William Laird
Dean, Ernest F.
Greenwald, W. J.
Grelling, L. A.
Hudnall, James S.
Johnston, Robert N.
Jones, Bobby M.
Long, Millard S.
Jones, Frank E.
Kempe, Gerald L.
Kidd, J. Pat
Key, Homer W.
Langham, Monroe O.
Morse, Joe V.
Moscrip, Robert, III
Neff, Harold O.
Parr, Charles F.
Patton, J. L.
Phillips, Charles G.
Pirtle, George W.
Pistole, Harry
Potter, Harold E.
Pownell, Galyn D.
Pryor, Ike T., III
Rennie, Preston George
Schultz, William P.
Sinclair, J. T.
Speller, Frank N., Jr.
Veselka, Ervin O.
Waid, W. O.

Van
Jones, Oliver W.

Vanderbilt
Gordon, Joseph C., Jr.
Howard, John D.

Victoria
Carter, Lee S.
Hamel, Roger C., Jr.
Lundy, Phillip D.
Morgan, John D.
Myers, Brantley G.
Norberg, Carl B.

Waco
Shanks, J. V.

Weslaco
Guerra, Arturo

West Columbia
Winkelmann, S. A.

Wichita Falls
Anderson, Carl T.
Balch, Sinclair
Barton, Richard A., Jr.
Beekman, Robert L.
Berry, Jack F.
Bilderback, Ervin G.
Bolstad, John H.
Boyce, John V.
Cameron, Paul E., Jr.
Canan, Thomas C.
Coleman, J. Pickens
Cook, Courtney E.
Coventon, E. L.
Cunningham, Ben A.
Darner, Richard R.
Davidson, K. Bruce
Dobyns, Rollie P.
Duggan, George L.
Duncan, Bill
Durossette, Cecil R.
Eads, John S.
Fagadau, Simion H.
Ford, Walter O., Jr.
Fosdick, Arthur R.
Foster, Kenneth W.
Garlick, J. M.
Gouldy, Roland
Graf, Arthur F.
Harmon, J. A.
Hill, Rodney M.
Huckaby, David R.
Hudson, Malcolm
Jordan, James Eugene
Kadane, Mike
Kerr, A. J.
Lewis, Roger
Magee, James F.
Martin, Frank H.
Maucini, Joseph J.
May, Donald T.
McAlpine, Billie Joe
McFarland, Curtis C.
Meisenheimer, David B.
Miller, Buck J.
Montfort, Kenneth
O'Neal, Lewis
Price, W. K.
Rathman, Raymond
Reavis, Harley N.
Reynolds, William Francis
Roberts, L. K.
Russell, Phillip R.
Saxon, Joseph, Jr.
Seydell, E. Morris
Seyfarth, Frederick W.
Sinclair, Walter Guy
Springer, Frederick Michael
Staples, William Ray
Stephens, Fred
Stephens, Maynard M.
Stine, Gordon R.
Winfrey, J. W.
Yeager, Hal W., Jr.
Zapp, James F.

Wickett
Wingate, R. G.

Wink
Ilfrey, Allen H.
Mueller, Carl B.
Wirsching, Joseph E.

Winters
Bybel, Edward J.
Cooke, Robert N.
Latimer, J. R., Jr.
Scott, Thomas E.

Wolters Air Force Base
Larson, Valdemar F.

Yorktown
Fish, Howard E.

UTAH

Kayesville
Henry, Kenneth Dale

Keetley
Cranmer, William H. H.

Salt Lake City
Bares, L. J. Ted
Bartlett, Howard F.
Brown, Arthur L.
Bywater, George G.
Gile, Wendell E.
Hager, Dorsey
Harrah, Otto W.
Hauptman, Charles A.
Lehner, Kenneth A.
Manuel, Tom
Mock, H. Byron
Nelson, Roy E.
Nightingale, William T.
Paine, M. D.
Parsons, C. C.
Quigley, W. Donald
Rosenblatt, Morris S.
Sanford, John Alden
Wade, James W.
Walters, George W.
Witt, Leroy C., Jr.

Vernal
Fields, H. B.
Hogan, Joseph R.

VERMONT

Middlebury
Welby, Charles W.

VIRGINIA

Alexandria
Fortine, Eugene A.

Arlington
Lott, Frederick S.

Blacksburg
Holland, Charles T.

Charlottesville
Hill, Harry H.
McGill, William

Fort Belvoir
Middleton, Douglas F.

Fort Lee
Harris, Elbert E., Jr.

Manassas
Krasnow, Shelley

Norfolk
Boylan, James P.
Moore, Leland Eugene

Wytheville
Seifert, Wilbur Houston

WASHINGTON

Bremerton
Stewart, James Milo

Olympia
Huntting, Marshall T.

Seattle
Richards, John S.
Slipper, S. E.
Watson, Ralph A.
Williams, John Rodney

Shelton
Crosby, H. Lance

Spokane
Martin, Armor B.
Smith, Dana W.

Trentwood
Smiley, James W.

WEST VIRGINIA

Charleston
Ballentine, George L.
Finch, Byron M.
Galpin, John
Krebs, Charles G.
Smith, Veleair C.
Waggener, Charles A.
Ziebold, William O.

Fairmount
Condit, Merlyn E.

Huntington
Hoover, Guy E.
Latimer, Warren E.

Morgantown
Edele, Robert H.
Laird, R. W.
Price, Paul Holland
Reger, David B.
Spindler, G. Ralph

Parkersburg
Johnston, Howard F.
Kiser, E. B.
Maddox, Gaiser D.
Speiden, E. F.

Sisterville
Wright, John C.

WISCONSIN

Madison
Ewing, Scott P., Jr.
Polster, Burl
Shorey, Edwin R.

Milwaukee
Pullen, Fletcher W.

Reedsburg
Gates, Herbert Roy

Superior
Murphy, Morgan

West Bend
Blazel, Carl L.

WYOMING

Bairoil
Heeter, William H.
Lannan, John C.
Plumley, Byron L.

Basin
Pond, Abbott S.

Casper
Allen, Bernard W.
Barnett, J. Howard
Bechtel, Russell G.
Bousfield, John C.
Brown, George G.
Burback, Fraser M.
Butler, Miff M.
Churchwell, R. M.
Crawford, James Gilmore
Cusator, James A.
Dickinson, Walter H.
Donham, James F.
Durr, W. L.
Ellis, George L.
Ferguson, Robert D.
Fraher, John A.
Fusselman, J. L.
Gamberg, Russell J.
Garthwaite, Delbert L.
Gleason, Hart C.
Goodin, George L.
Griswold, John Anthony
Harrison, E. T.
Harvey, Thomas B., Jr.
Heath, John L., Jr.
Hoenshell, David T.
Jones, Harold S.
Lang, John E.
Larsen, Raymond M.
McCarthy, John Curtis
McDowell, Oliver G.
Olson, Henry D.
Parrent, Kenneth G.
Partridge, John F., Jr.
Patterson, Robert W.
Peta, Louis C.
Pierson, Darrell S.
Redwine, Fletcher H.
Roadifer, Roy E.
Robbins, Raymond W.
Slaby, Robert J.
Smalley, Ralph, Jr.
Smith, Ashleigh W.
Spidell, William H.
Spieles, Earl L.
Sylvester, William C.
Thomas, Augutus Lee, Jr.
Tyler, Charles D., Jr.
Wallis, Hugh A.
Walters, J. H.
Zagar, Frank Stanley

Cheyenne
Bretches, Otis D.

Cody
Falkingham, D. H.
Gilbert, James Cornelius
Grove, Richard E.
Kahla, William R.
Mathews, Lee M.
Pollock, Charles B.
Westfall, Millard F.

Glenrock
Byers, Rex H.

Grass Creek
Stewart, Joseph E.

Lamont
Bellamy, Ben C.

Lance Creek
Winn, J. Spencer

Lander
Giles, Robert B.

Laramie
Biggs, Paul
Espach, Ralph H.
Zaffarano, Richard

Linch
Curtis, Lawrence B.

McFadden
Cordiner, Frank S.
England, Marshall J.

Medicine Bow
Goode, Gordon W.

Midwest
Allen, Thomas N.

Newcastle
Koch, Herb A.
Roy, Willard L.
Warkentin, Ralph W.
Young, James E.

Powell
Morton, Leland Matthews

Riverton
Horne, J. D.
Johnston, Myron T.
Lear, Bert A.
Wilson, William E.

Rock Spring
Callahan, William L.
Fidlar, M. M.
Fisher, S. J.
Kratka, Frank H., Jr.
Myers, Robert Glen
Sanna, Joseph J.
Schuleman, School
Simon, J. T.
Strojek, John J.
Zlomke, Charles D.

Thermopolis
Hoffman, George W., Jr.
Larson, Robert E.

Worland
Fair, Robert A.
Kleppinger, Kenneth B.
Schafer, Elwood W.
Strampe, Wesley
Swift, Virgil Neil

ALASKA

Anchorage
Kreitlow, Edwin J.
Ryan, Irene E.

Fairbanks
Mathews, Ted C.

CANADA

ALBERTA

Calgary
Aaring, Floyd D.
Allinder, William F.
Babson, Edmund C.
Bannantine, George A.
Berlie, Elmer M.
Bernhard, William E.
Bird, S. Frederick
Blackmore, H. F.
Bonsall, James G.
Brusset, Henry
Brusset, John A.
Castelain, M.
Chakravorty, S.
Charles, William W., Jr.
Connor, Eric J.
Corey, B. H.
Cummer, R. F.
Dlugos, J. W.
Downing, John A.
Dumett, C. W., Jr.
Erick-Mulder, F. R.
Eubanks, Erdie B., Jr.
Falconer, W. L.
Frye, Charles C.
Fulton, John M.
Funkhouser, E. M.
Gaines, Tom
Galloway, John O.
Galvin, E. A.
Gillespie, Bart W.
Glenn, William D.
Gustafson, J. D.
Halcrow, A. F.
Hale, John D.
Garde-Hansen, H.
Hawkins, Dallas E., II
Hilchie, Douglas W.
Holmberg, Hjalmar B.
Hotchkiss, Harley N.
Hughes, Douglas F.
Hughes, H. Edwin
Humphries, R. G.
Hunter, Harry M.
Jaenen, Raymond C. J.
Justen, John Joseph
King, J. G.
Klein, F.
Knode, W. F.
Landreth, Thomas C., Jr.
Langston, John F.
Link, Theodore A.
Little, H. G.
Lockwood, R. P.
Mackenzie, W. D. C.
Mannister, Keith J. E.
Martin, R. E.
Maughan, John B.
McAvoy, Ralph E.
McCutchin, John A.
McKay, John R.
McPherson, William J.
Miller, Lloyd E.
Mims, Dow
Murray, A. S.
Nichols, Norval Wallace
Nelson, David R.
Olson, C. H.
Parsons, Harold E.
Paterson, John F.
Pot, R.
Putman, S. J.
Ratke, Edwin S.
Rawles, William P.
Richards, Sidney B.
Rousseau, R. J.
Rylands, A. T.
Schluntz, E. K.
Sears, J. R.
Smith, Owen J. E.
Soul, Norman
Spadling, J. G.
Stephenson, A. H.
Stevens, Leonard Charles
Stout, K. R.
Suter, Hans H.

Taylor, C. J.
Taylor, Harry A.
Taylor, M. K.
Taylor, M. W., II
Taylor, Vernon
Tennant, Robert H.
Trafford, Edward
Webster, Gordon William
White, Ronald J.
Wilson, E. D.
Wilson, Owen J. E.
Young, J. W.
Zwicky, Robert W.

Edmonton
Bailey, R. L.
Blanchard, E. M.
Bogert, William M.
Bohme, Victor E.
Clark, James D.
Curran, Arthur H., Jr.
Dickson, Ronald
Dranchuk, P. M.
Fisher, Royden O.
Freeborn, W. D.
Gregg, John W.
Halkers, A. A.
Harvie, James A.
Hinkle, Henry W.
Holan, A. F.
Lineham, J. G.
Lougheed, D. D.
McDonald, James B.
McDonald, William L.
McOsker, Dick E.
Mills, Ralph D.
Naramore, Chester
Newman, W. R.
Samoil, Leo Lloyd

Grand Prairie
Cummer, Roy P.

Lloydminster
Johnson, Grady E.

Olds
Hedges, Glenn N.

Violet Grove
Larson, John H.
Quance, Robert J.

BRITISH COLUMBIA

Dawson Creek
Koy, Billy C.

Duncan
Blanc, Francis E.

Vancouver
Banks, C. A.
Forward, F. A.
Magnolo, Guiseppe
Simpson, J. D.

Victoria
Hayes, Albert O.
Lineham, John D.

MANITOBA

Bradon
Allan, J. Donald

Virden
Atkinson, Ralph F.
Cleland, N. A.
Kilik, Morris
Wright, Walter G.

NOVA SCOTIA

Halifax
Cameron, Alan E.

ONTARIO

Ottawa
Ignatieff, Alexis

Petrolea
Fairbank, Charles O.

Kingston
Lord, T. V.

Toronto
Burton, Fred R.
Coste, E. Frank
Neal, Earl Seaton
Wallace, W. S.

Welland
Makepence, C. E.

QUEBEC

Montreal
Forbes, J. M.
Gerow, Carlyle
Howe, Randolph W.
Letendre, Gerard
MacEwan, James
Watson, R. M.

Quebec
Jones, I. W.

SASKATCHEWAN

Estevan
Huddleston, William F.

Lloydminster
Peschke, George A.

Regina
Dixon, R. K.
Gateman, John C.
Leith, H. E.
Roe, William H.

MEXICO

FEDERAL DISTRICT

Coatzacoalcos
Blanco, Nestor W.
Enrique, Huerta A.
Rivero, O. G.

Mexico City
Aldredge, R. F.
Basurto, David Phillips
Blair, Albert E.
Calleya, Georges X.
Carty, John T.
Cardenas, J. M. De La Garza
De La Torre, I. Carcia
Flores, Teodoro
Frost, Noel
Garfias, Valentin R.
Guzman, Eduardo J.
Hefferan, Juan V.
Moran, Luis
Nieto, G. L.
Ruiz M., R.
Salas, G. P.
Skaln, Hubert J.
Underwood, George W.
Velasco, Miguel Tejada
Vistuer, E. Lozano

VERACRUZ

Paza Rica
Gonzalez, Javier Luna

TAMAULIPAS

Reynosa
Gutierrez-G., S.

Tampico
Cochran, R. B.

CENTRAL AMERICA

WEST INDIES

CUBA

Cabaiguan
Gray, Robert

Habana
Engleman, Rolf

DOMINICAN REPUBLIC

Cuidad Trujillo
Zoppis, Renta De Sena

TRINIDAD

Point-a-Pierre
Haley, Arthur H.

SOUTH AMERICA

ARGENTINA

Buenos Aires
Martinez, Jose O.
Williams, Thomas J.

BOLIVIA

La Paz
Aldazosa, J.
Hinojosa, E.
Mauri V., E. T.

Potosi
Soux H., Augusto

Santa Cruz de la Sierra
Loza, Alfonso Romero

Camiri
Delius, Carlos E.

BRAZIL

Para
Koch, Herman J.

Rio de Janeiro
Clemens, Wilbur M.
De Oliveira, Avelino Ignacio
Link, Walter K.
Oddone, Decio Saverio

SALVADOR

Bahia
Brantly, John Edward, Jr.
De Andrade, Paulo Varjao

Sao Paulo
Gardner, A. Maclay
Moraes, Jose E.

BRITISH GUIANA

Georgetown
Davison, H. A.

CHILE

Chuquicamata
Hare, Harold J.

Punta Arenas
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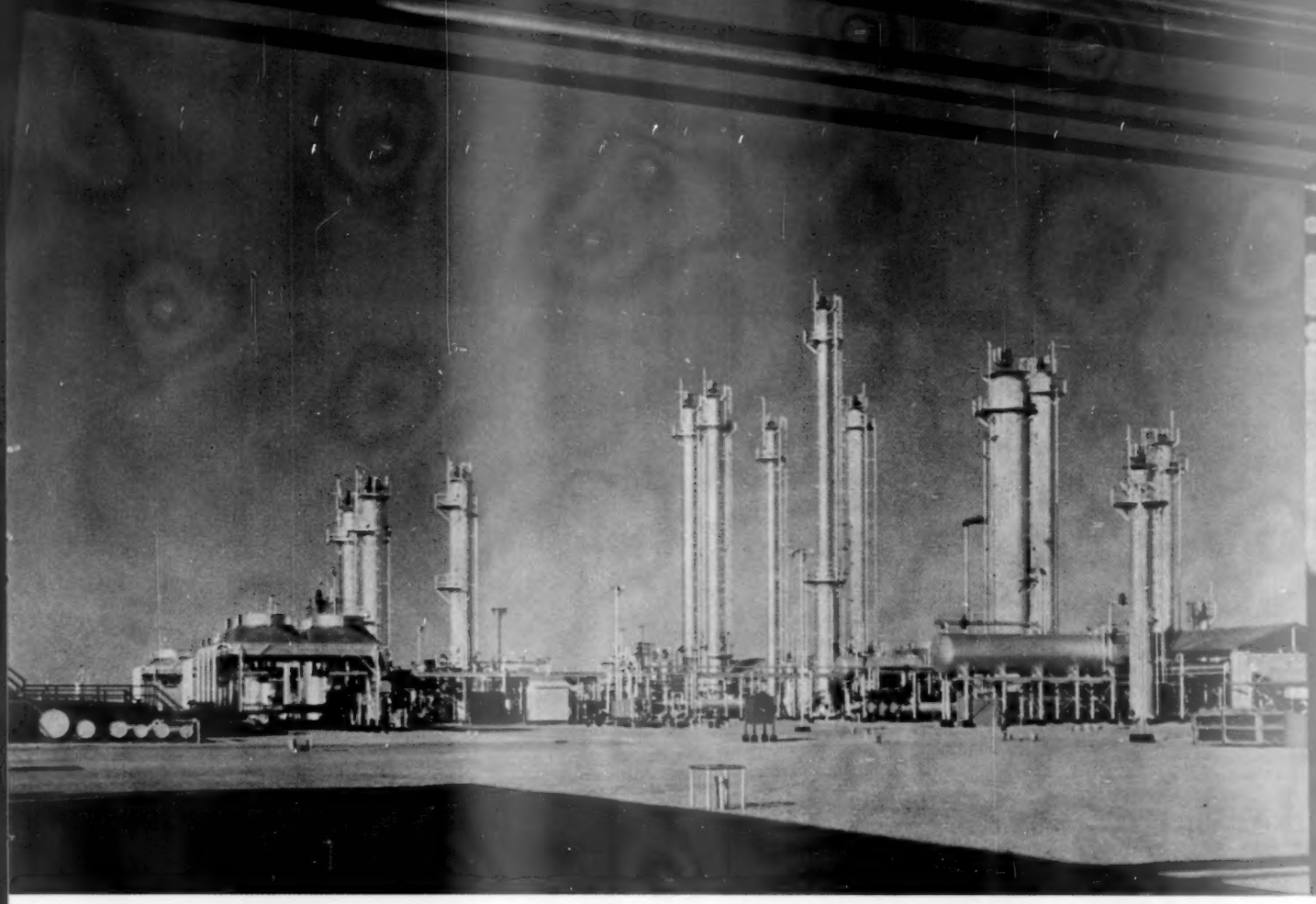

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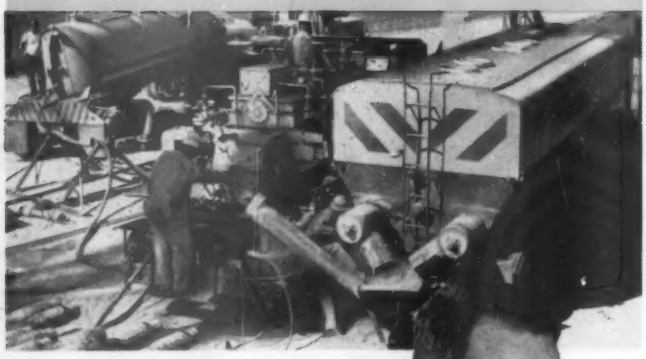

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